

AUTHORIZATION OF APPROPRIATIONS FOR THE NATIONAL
AERONAUTICS AND SPACE ADMINISTRATION FOR FISCAL
YEAR 1987

SEPTEMBER 29 (legislative day, SEPTEMBER 24), 1986.—Ordered to be printed

Mr. DANFORTH, from the Committee on Commerce, Science, and
Transportation, submitted the following

REPORT

together with

ADDITIONAL VIEWS

[To accompany S. 2714]

The Committee on Commerce, Science, and Transportation, to which was referred the bill (S. 2714) to authorize appropriations for the National Aeronautics and Space Administration for research and development, space flight, control and data communications, construction of facilities, and research and program management, and for other purposes, having considered the same, reports favorably thereon with an amendment in the nature of a substitute and recommends that the bill do pass.

PURPOSE OF THE BILL

The purpose of this bill is to authorize appropriations to the National Aeronautics and Space Administration (NASA) totaling \$7,795 million for fiscal year 1987, as follows:

	<i>Budget request</i>	<i>Committee authorization</i>
Fiscal year 1987:		
Research and development	\$3,003,100,000	\$3,112,700,000
Space flight, control, and data communica- tions	3,069,000,000	3,096,000,000
Construction of facilities.....	181,300,000	161,300,000
Research and program management	1,441,000,000	1,425,000,000

71-010 O

5263-24

LEGISLATIVE HISTORY

In February 1986, the administration submitted its fiscal year 1987 budget request for NASA to Congress. The Committee considered the budget request and related policy issues in hearings on March 20, April 10, 16, 23, May 8, and August 5. Testimony was received from the NASA Administrator, the Secretary of the Air Force, and the Director of the Office of Commercial Space Transportation of the Department of Transportation (DOT). Also testifying before the Committee were representatives of the aerospace industry, the space science and applications communities, and other outside witnesses.

On August 5, Senators Gorton and Danforth introduced the National Aeronautics and Space Administration Act of 1987, S. 2714. Also on August 5, Senator Riegle, with Senators Hollings, Gore, and Rockefeller, introduced S. 2718, the Civilian Space Program Restoration Act of 1986.

On August 14, 1986, the Committee considered S. 2714 and S. 2718. The Committee ordered S. 2714 to be reported with an amendment in the nature of a substitute.

COMMITTEE ADJUSTMENTS TO NASA REQUEST FOR FISCAL YEAR 1987—SUMMARY

Fiscal year 1987	Administration request	Committee authorization
Research and development:		
Space transportation capability development.....	\$465,500,000	\$515,500,000
Space station.....	410,000,000	400,000,000
Physics and astronomy.....	539,400,000	522,400,000
Life sciences.....	74,700,000	74,300,000
Planetary exploration.....	323,300,000	374,300,000
Space applications.....	526,600,000	557,600,000
Technology utilization.....	13,300,000	13,300,000
Commercial use of space.....	32,000,000	27,000,000
Aeronautical research and technology.....	376,000,000	371,000,000
Transatmospheric research and technology.....	45,000,000	40,000,000
Space research and technology.....	180,200,000	200,200,000
Space tracking and data systems.....	17,100,000	17,100,000
Total.....	3,003,100,000	3,112,700,000
Space flight, control, and data communications:		
Space shuttle production and operational capability.....	745,400,000	884,400,000
Space transportation operations.....	1,524,700,000	1,350,700,000
Space and ground networks, communications, and data systems.....	798,900,000	860,900,000
Total.....	3,069,000,000	3,096,000,000
Construction of facilities.....	181,300,000	161,300,000
Research and program management.....	1,441,000,000	1,425,000,000
Grand total.....	7,694,400,000	7,795,000,000

SUMMARY OF MAJOR PROVISIONS

For fiscal year 1987, the Committee's NASA authorization bill authorizes \$7,795,000,000, of which \$3,112,700,000 is for research and development; \$3,096,000,000 is for space flight, control, and data communications; \$161,300,000 is for construction of facilities; and \$1,425,000,000 is for research and program management.

The Space Transportation Capability Development budget for \$515,500,000 is \$50,000,000 greater than the fiscal year 1987 NASA budget request of \$465,500,000 and provides for the development of alternate launch options for the planetary missions that were previously scheduled for a shuttle/Centaur launch and deployment. Also included in the fiscal year 1987 authorization is funding for the United States/Italian Tethered Satellite System and the Orbital Maneuvering Vehicle.

The Committee has provided \$400,000,000 for the completion of Phase B definition and design studies for the permanently manned space station and for the initiation of phase C/D development. The Committee's space station recommendation is \$10,000,000 below the administration's request of \$410,000,000.

The budget for the Space Sciences programs for fiscal year 1987 is \$971,000,000, compared to the administration's request of \$937,400,000. The Committee's Space Science recommendation retains the administration's budget request for research and analysis in Physics and Astronomy and in Planetary Exploration and maintains the science teams associated with the Hubble Space Telescope, Galileo, and Ulysses spacecraft, each of which were to have been launched from the Shuttle in 1986.

The Space Applications funding for fiscal year 1987 is \$557,600,000, compared to the administration's budget request of \$526,600,000. Space Applications funding retains the administration's request for Materials Processing in Space and authorizes \$85 million for the Advanced Communications Technology Satellite (ACTS) program and \$113 million for the Upper Atmosphere Research Satellite (UARS) program. Finally, the Space Applications authorization provides \$19 million for the new start of the Ocean Topography Experiment (TOPEX) program.

The Committee has authorized \$27,000,000 for Commercial Use of Space, compared to the administration's request of \$32,000,000.

The Committee's authorization provides \$371,000,000 for Aeronautical Research and Technology, compared to the administration's request of \$376,000,000. Transatmospheric Research and Technology is authorized at a funding level of \$40,000,000, which is \$5,000,000 below the administration's budget request.

Space Research and Technology is funded at a level of \$200,200,000, compared to the administration's request of \$180,200,000.

The authorization for Tracking and Data Acquisition Advanced Systems is maintained at the fiscal year 1987 administration request of \$17,100,000.

The total Research and Development budget for the above-mentioned programs for fiscal year 1986 is \$3,112,700,000, compared to a fiscal year 1987 Budget Request of \$3,003,100,000 and a fiscal year 1986 funding level of \$2,614,300,000.

Within the Space Flight, Control, and Data Communications budget of \$3,096,000,000, the Space Shuttle Production and Operational Capability is funded at a level of \$884,400,000. This funding level will enable NASA to redesign and requalify the Shuttle Solid Rocket Booster and to implement other recommendations of the Rogers Commission.

Shuttle Operations activities within Space Flight, Control, and Data Communications are funded at a level of \$1,350,700,000. This funding provides for the procurement of the external tanks, the solid rocket motors and boosters hardware; flight operations; and launch and landing activities.

Finally, within Space Flight, Control, and Data Communications, \$860,900,000 is made available for space and ground networks, communications, and data systems, most of which supports the Tracking and Data Relay Satellite System (TDRSS).

The Committee recommendation for Construction of Facilities for fiscal year 1987 is \$161,300,000, which is \$20,000,000 less than the administration's budget request. The Committee recommendation for Research and Program Management is \$1,425,000,000, compared to the administration's budget request of \$1,441,000,000.

S. 2714, as reported by the Committee, authorizes the construction of a replacement Space Shuttle if the President recommends this action and if funds are made available in addition to those provided in this bill.

This bill directs the NASA Administrator to review the report of the National Commission on Space and report to Congress, not later than March 1, 1987, an implementation plan and a specific agenda for the next 5 years.

As reported by the Committee, S. 2714 establishes within the Executive Office of the President a National Aeronautical and Space Council, which would be chaired by the Vice President and whose additional members would include the NASA Administrator, and the Secretaries of Defense, Transportation, Commerce, and State.

S. 2714, as reported by the Committee, includes language prohibiting the use of the space station to carry or deploy nuclear weapons or any other weapons of mass destruction.

This bill also authorizes \$2,275,000 for the Office of Commercial Space Transportation of DOT for fiscal year 1987.

S. 2714, would require NASA to establish in its annual budget request a line item for quality assurance, reliability, and safety.

Finally, this bill would make it the sense of the Senate that no bill, resolution, or amendment to deplete from the Consolidated Rail Corporation (Conrail) cash be considered by the Senate until the Committee has reviewed the effect of such a proposal on the sale of Conrail.

RESEARCH AND DEVELOPMENT—\$3,112,700,000

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT—\$515,500,000

The Committee has authorized \$515.5 million for fiscal year 1987, \$50 million more than the administration's request, and within Space Transportation Capability Development, the Committee makes the following authorizations:

Summary of funding levels, fiscal year 1987

Spacelab.....	\$66,700,000
Upper stages.....	200,100,000
Engineering and technical base.....	119,900,000
Payload operations and support equipment.....	50,600,000
Advanced programs.....	16,600,000
Tethered satellite systems.....	11,600,000
Orbital maneuvering vehicle.....	50,000,000
Total.....	515,500,000

The principal areas of activity in Space Transportation Capability Development are the Spacelab, the upper stages that place satellites in high altitude orbits, the engineering and technical base support at NASA centers, payload operations and support equipment, advanced programs study and evaluation efforts, and the development and first flight of the United States/Italy Tethered Satellite System (TSS) and the development of the Orbital Maneuvering Vehicle.

The Spacelab is a major element of the Space Transportation Systems (STS) program and provides a versatile, reusable laboratory which will be flown to and from Earth orbit in the Shuttle orbiter cargo bay. The development program which has been carried out jointly by NASA and the European Space Agency (ESA) continues with the procurement of hardware for the Dedicated Discipline Laboratory, the Hitchhiker System, the Spacelab Pallet System, the Space Technology Experiment Platform, and the initial lay-in of spares.

Upper stages deploy payloads in orbits and trajectories beyond the capability of the Shuttle alone. The program provides for procurement of stages for NASA missions, for technical monitoring and management of government and commercial upper stages, and a Solid Rocket Motor integrity program to establish an engineering data base for upper stage components. In June, NASA terminated the Shuttle/Centaur upper stage program due to continued technical and safety concerns. The future of the Centaur as a separate upper stage for NASA missions is undecided.

The engineering and technical base provides the engineering, scientific, and technical support required at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL) for research and development.

Payload operations and support equipment provides for developing and operating the ground and flight systems necessary to support the STS payloads during prelaunch processing, on-orbit mission operations, and, when appropriate, post-landing processing. Included within this program area are STS support services for NASA payloads, satellite servicing tools and techniques development, flight demonstrations, and multimission payload support equipment.

In its advanced programs, NASA identifies, defines, and evaluates potential future space programs. NASA's activity is focused on six major areas: advanced missions, satellite services, spacecraft systems, advanced transportation systems, crew systems, and generic space system capabilities, NASA conducts advanced development activities to improve performance and reliability signifi-

cantly and to reduce future program risks and development costs through the effective use of new technology.

The TSS, a joint Italian/United States development effort, will provide a new capability for conducting space experiments in regions remote from the Shuttle orbiter. The objectives of the initial TSS mission are twofold: (1) to verify the controlled deployment, operation, and retrieval of the TSS, and (2) to quantify the interaction between the satellite/tether and space plasma in the presence of a current drawn through the tether.

The development of the Orbital Maneuvering Vehicle, initiated in 1986, will provide a capability for payload delivery, retrieval, and servicing beyond that currently available in the Space Transportation System.

Spacelab

The first Spacelab operational flight (SL-3) and the second development flight (SL-2) were successfully flown during fiscal year 1985. The first reimbursable flight, Deutschland-1 (D-1), was flown during the first quarter of fiscal year 1986. Astro-1, an astronomical observation of Halley's comet, and an Earth Observatory Mission (EOM-1/2), a mission flying several experiments previously flown on SL-1, were scheduled for shuttle flights in fiscal year 1986 prior to the accident of the space shuttle *Challenger*. Their assignment to future shuttle missions is pending.

Upper stages

In upper stages, NASA and the Department of Defense (DOD) initiated a joint development program in fiscal year 1983 to use the Centaur as an STS upper stage. In June, NASA terminated the Shuttle/Centaur Program. After the accident of the space shuttle *Challenger*, there were heightened concerns about the safety of flying this highly volatile cryogenic system aboard the Shuttle, particularly in combination with the Radioisotope Thermoelectric Generators (RTG's) which are required for the planetary missions Galileo and Ulysses. In terminating this program, NASA determined that, even following certain modifications identified by ongoing reviews, the resultant upper stage would not meet safety criteria being applied to other cargo or elements of the Shuttle System. This decision will not affect Centaur programs other than those which were planning to use the Shuttle.

The Inertial Upper Stage (IUS) was developed under a DOD contract to provide the capability to place payloads of up to 5,000 pounds into geosynchronous orbit. The IUS that was mated to the tracking and Data Relay Satellite (TDRS-2), a payload onboard the STS 51-L *Challenger*, was destroyed in that accident.

The commercially developed Payload Assist Modules (PAM) provide low cost transportation, principally for commercial spacecraft, from the Shuttle's low Earth orbit to geosynchronous orbit. The Delta class PAM-D is capable of injecting up to 2,750 pound payloads into geosynchronous transfer orbit. The Delta class PAM-DII is capable of placing a 4,100 pound payload into geosynchronous transfer orbit and was used for the first time in launching an RCA payload for STS 61-B in November 1985. The Atlas-Centaur class (PAM-A) is capable of inserting 4,400-pound payloads into the

same orbit and was system-qualified in late 1984. Forty PAM-D's have been successfully launched on the Delta, Atlas, and Space Shuttle. There have been 20 consecutive successful PAM-D missions as of January 1986.

The Transfer Orbital Stage (TOS) is a three-axis stabilized perigee stage which is being commercially developed by the Orbital Science Corporation (OSC) for use in the Shuttle. It will have the capability of placing 6,000 to 13,000 pounds into geosynchronous transfer orbit and thus bridges the gap between PAM-DII and Centaur. The scheduled launch availability is late 1987. The TOS has been selected as the upper stage for the Mars Observer mission.

The Apogee Maneuvering Stage (AMS) is a three-axis stabilized liquid propellant apogee stage which is also being commercially developed by OSC for the use in the shuttle. It will be able to place 5,200 pound payloads into geosynchronous transfer orbits when used alone, or 6,500 pounds into geosynchronous orbit when combined with a TOS. Projected availability is late 1987.

NASA began the Solid Rocket Motor Integrity program during fiscal year 1984 to establish an urgently needed engineering data base for use of composite materials in upper stage motor nozzles. NASA is examining physical and mechanical properties of selected components and is developing means of instrumenting manufacturing processes and their impact on material properties. Motor testing will be conducted to verify analysis and create an engineering data base.

Payload operations and support equipment

Payload operations funding is required to service payloads for scheduled NASA launches. Shuttle payloads will continue to receive support during this year, but at a more reduced level than previously scheduled. Further, efforts will continue to provide the means to maintain and repair satellites or-orbit and to improve the efficiency of on-orbit operations. This work will provide the experience necessary to realize the shuttle's potential for satellite servicing and on-orbit assembly.

Advanced programs

In fiscal year 1986, major emphasis has been placed on system concept definition and on key advanced developments in crew systems, geostationary Earth orbital unmanned platforms, reusable Orbital Transfer Vehicles (OTV's) new capability mission kits for orbital maneuvering vehicles, future tethered systems applications, satellite servicing systems near and remote from the orbiter, and second generation Shuttles. A major goal continues to be the definition of the space elements needed for space operations over the next twenty years.

Tethered Satellite System

The development of a TSS will provide a new facility for conducting space experiments at distances up to 100 kilometers from the space shuttle orbiter while being held in a fixed position relative to the orbiter.

The United States is responsible for overall program management, orbiter integration, and hardware development of the deploy-

ment mechanism, which was initiated in fiscal year 1984. The Italians initiated the satellite hardware development in 1984. They are responsible for the satellite development and instrument and experiment integration.

Fiscal year 1987 funding will continue the hardware design and development. The planning estimate for the total development cost for the U.S. activities remains at \$60 million.

Orbital Maneuvering Vehicle

The Orbital Maneuvering Vehicle (OMV) will extend the ability of the STS to conduct orbital operations with spacecraft and payloads beyond the limits of the baseline STS. The OMV will be reusable, will remain in space, and will operate as far as 800-1,400 nautical miles from the orbiter. Under direct human control, it will deliver, maneuver, and retrieve satellite payloads to and from altitudes or inclinations beyond the existing STS capacity; reboost satellites to original operational altitudes or higher; deliver multiple payloads to different orbital altitudes and inclinations in a single flight; and safely deorbit satellites which have completed their useful life.

In June, NASA selected TRW as the prime contractor for OMV hardware development. Fiscal year 1987 funds will be used to continue this development, leading to a first flight in 1991.

COMMITTEE COMMENTS

The Committee's authorization of \$515.5 million for Space Transportation Capability Development is \$50 million more than the administration's budget request. This additional authorization is achieved by an increase of \$115 million for Upper Stages and decreases of \$23 million to Spacelab, \$22 million to Payload Operations and Support Equipment, and \$20 million to the OMV.

Due to the *Challenger* accident and the hiatus in shuttle flights, NASA will not be flying and supporting Spacelab missions in fiscal year 1987 and in the future at the rate previously anticipated. Consequently, a reduction to the Spacelab Program of \$23 million from the administration's request can be accommodated without disturbing the fundamental capabilities required to fly and support Spacelab missions in the future.

The Committee is aware that new weight constraints on future shuttle missions could seriously limit Spacelab capabilities. The Committee expects to be kept informed on the analysis of this issue and on any other options that may be considered to compensate for any reductions in Spacelab capabilities.

For the same general reasons that the Committee has reduced its authorization for Spacelab, the Committee has also reduced the authorization for Payload Operations and Support Equipment \$22 million below the administration's request. With fewer shuttle missions in fiscal year 1987 and beyond, NASA will have fewer requirements to develop and place into operational status the ground and flight systems necessary to support the Shuttle payloads during prelaunch processing, on-orbit mission operations, and, when appropriate, postlanding processing. Therefore, the Committee believes that NASA can accommodate this reduction without adverse-

ly affecting its Payloads Operations and Support Equipment capabilities.

The Committee's authorization of \$50 million for the OMV program, \$20 million below the administration's request, is no indication of any lack of support for this program; the reduction is made in response to budgetary pressures. The Committee continues to believe that the multi-dimensional capabilities of the OMV will be a critical asset to many Shuttle missions and activities, such as the delivery of payloads to orbits above 150 nautical miles, spacecraft delivery requirements on polar orbit missions, and retrieval of spacecraft which have experienced equipment failure or which require servicing.

The Committee recognizes that the first requirement for the OMV is to reboost the Hubble Space Telescope (HST). With the delay in the launch of the HST from late 1986 to late 1988, the Committee believes that the OMV program can accommodate a reduction of \$20 million. The Committee emphasizes the importance of maintaining the funding level at a minimum of \$50 million, however, so that the OMV is available for a 1991 launch and its first reboost requirement of the HST in 1991.

With the cancellation of the Shuttle/Centaur Program, NASA must now examine alternate launch options for three of its planetary programs, Galileo, Ulysses, and Magellan. The Committee recognizes that there are many factors to consider in determining the means of launch for these missions—cost, safety of the Radioisotope Thermoelectric Generators associated with the spacecraft, launch dates, and weight landing constraints, to name a few. Regardless of the launch option that is chosen for each of the three planetary missions, NASA will be faced with additional budget requirements to implement the respective launch option decisions. Therefore, the Committee has authorized an additional \$115 million for Upper Stages.

Accompanying the decision to cancel the Shuttle/Centaur Program are programmatic termination costs of approximately \$32 million. NASA is expected to accommodate those termination costs within the additional authorization for Upper Stages. Finally, the Committee recognizes that this additional authorization for Upper Stages is based on a budgetary assumption, not a programmatic decision, of a Shuttle launch of Galileo and Ulysses, using IUS. Should NASA choose to launch either or both of these planetary missions on a Titan IV expendable launch vehicle, the Committee recognizes that this will introduce additional budgetary requirements for fiscal year 1987. The Committee expects to be notified by NASA as soon as a final launch plan is adopted for these critical space science payloads.

SPACE STATION—\$400,000,000

The Committee has authorized \$400 million for fiscal year 1987, \$10 million below the administration's request.

The space station will enhance the Nation's space science and applications programs and will further the commercial utilization of space, while stimulating advanced technologies. A vigorous but deliberately paced Space Station Program will permit us to maintain

the preeminence in space our Nation has attained through various manned and unmanned programs.

The space station will be a multipurpose facility providing a permanent human presence in space to conduct scientific and technical research, to support unique commercial activities, and to perform more efficiently operational tasks in space, such as satellite servicing.

President Reagan encouraged international participation in the Space Station program in his 1984 State of the Union address. Canada, member states of ESA, and Japan have responded enthusiastically. Memoranda of Understandings (MOU) for the definition and preliminary design phase were executed with Canada, ESA, and Japan in the spring of 1985, concurrent with the initiation of the NASA definition contracts. These international partners are undertaking parallel definition and preliminary design studies to identify space station elements that each of them may consider for development.

ESA, Canada, and Japan have signed agreements to continue phase B preliminary design work for specific hardware elements. The subject of Canada's phase B agreement is a Mobile Servicing Center, which will be used in the assembly of the space station and in the service of attached payloads. The subject of Japan's Phase B agreement is a pressurized, multipurpose, R&D module, while ESA will continue its Phase B preliminary design studies of a permanently attached pressurized laboratory module, a polar-orbiting platform, a man-tended free flyer, and a co-orbiting platform.

The program definition phase has featured continuing emphasis on and iteration of user requirements. The space station will be designed to permit the system to evolve through time to provide greater user utility and operational capabilities. Its manned and unmanned elements will be designed to facilitate maximum on-orbit maintainability and restorability, operational autonomy, human productivity, and simplified user interfaces. Implicit in these objectives is the need to optimize the synergistic effects of the man/machine combination in space via automation, robotics, and artificial intelligence. The space station facility (core and associated platforms) will be placed and maintained in low-Earth orbit.

During the definition period, NASA is evaluating various subsystems changes to the space station options. Changes to the reference configuration are being made to arrive at the optimum baseline configuration considering user requirements, systems efficiency, development and operations cost, and growth potential. Changes to the initial "power tower" reference configuration which have been baselined so far are: (1) dual keel; (2) "figure 8" module pattern; (3) 43.7 feet module length; (4) 14.7 psi cabin pressure; (5) assembly altitude of 220 nautical miles and a minimal operation altitude of 250 nautical miles; and (6) 10 to the minus 5 g's microgravity level.

Also during the definition program, NASA completed a congressionally mandated study to examine the feasibility of initially building and deploying a man-tended space station followed with a three to five year phase-in of a permanently manned capability.

The definition and preliminary design phase will continue through fiscal year 1987 and will provide the technical and programmatic plan for the Space Station Program, including the com-

pletion of the detailed definition and preliminary design, the analysis and integration of national and international user community requirements, and the advanced development of technology options.

The development phase is scheduled to begin in fiscal year 1987 with the initiation of work package contracts, which are planned to begin incrementally, starting in mid-fiscal year 1987. This contracted effort, as currently contemplated, will be divided into four major categories, which may be adjusted as a result of the definition studies and/or international participation. Present planning calls for one category to include the common modules, the environment control and life support systems, the outfitting of laboratory and logistics modules, the auxiliary propulsion systems and related applications software. A second category will consist of the distributed systems (including communication and tracking, data management systems, thermal system, mechanisms, and the connect/interconnect module); trusses and other structural items; the guidance, navigation and control system; the resources integration and shuttle interface analysis; and related applications software. The third category includes the platforms, the facilities and techniques for the servicing of free flyers and other space hardware, as well as the outfitting of laboratories and related applications software. The final category consists of the power generation, power storage, and power management and distribution.

The design and development of the modules, structures, distributed subsystems and platforms will be phased to optimize fabrication, assembly, and checkout flow times to support an initial launch of space station elements in the early to mid-1990's.

COMMITTEE COMMENTS

As the Space Station Program has progressed in its preliminary definition and design studies and as the need for a permanently manned presence in space becomes more apparent, the Committee maintains the strong belief that the space station is our Nation's next logical step in space. Accordingly, the Committee has authorized for fiscal year 1987 \$400 million for NASA to complete its definition and design studies and to initiate Phase C/D development.

With the development in February 1986 of the Soviet Mir space station and with the current dual operation of the Mir and the Salyut 7 space stations, the Soviet Union has demonstrated an alarmingly robust manned presence in space vis-a-vis that of the United States. Regrettably, during this temporary pause in our space program, the Soviet Union will be able to lengthen its lead over the United States in long-duration exposure in space. This alone should be reason enough for the United States to pursue aggressively its own manned space station if the United States expects to reaffirm its preeminence in space.

Also, the Committee recognizes that industry and potential international partners alike will be ready to initiate Phase C/D development in mid-1987, and for the Space Station Program to utilize its human and budgetary resources most effectively, actual development should in fact commence in fiscal year 1987. To delay the initiation of development will only introduce unnecessary costs and inefficiencies into the program.

The Committee maintains its belief that the space station is a facility that should be used for peaceful purposes. Accordingly, the Committee has approved language in fiscal year 1987, as it has done for the past two years, which reaffirms this position. Section 6 of S. 2714, as reported by the Committee, restates article IV of the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Celestial Bodies. It is not the Committee's intent to preclude DOD from conducting research and development activities on the space station, but it is the Committee's interest to ensure that the space station is used for peaceful purposes, as it has been characterized since the program's inception.

Despite the Committee's support of the Space Station Program, it does have concerns about recent developments concerning the proposed design, work packages, and NASA Center responsibilities. The Committee expects to be kept well-informed of any developments concerning the Space Station Program, and it expects NASA to implement a management plan that can best accomplish the goals and objectives of the Space Station Program.

At the same time, the Committee is pleased with NASA's efforts to incorporate the views of the user community into the design of the Space Station Program. The Committee is concerned, however, that the views of the user communities are not being integrated into the international negotiations pertaining to the legal regime and operations of the space station. The Committee recommends that NASA assess this situation and implement a mechanism that ensures such user inputs, especially with respect to liability and patent provisions.

SPACE SCIENCES—\$971,000,000

The Committee authorization for the Space Sciences—Physics and Astronomy, Planetary Exploration, and Life Sciences—is \$971 million, \$33.6 million above the fiscal year 1987 administration request.

PHYSICS AND ASTRONOMY—\$522,400,000

The Committee recommends \$522.4 million for Physics and Astronomy, compared to the administration's request of \$539.4 million.

Within the Committee's recommendation for Physics and Astronomy, the Committee specifically authorizes \$51.1 for Research and Analysis and \$64.4 million for the Suborbital Program, both as requested by the administration, and \$125.7 million for Mission Operations and Data Analysis. Also, the Committee authorizes \$95.9 million for the HST, \$45.5 million for the Gamma Ray Observatory, and \$83.1 million for Shuttle/Spacelab Payload Development.

The major objective of the Physics and Astronomy program is to increase our knowledge of the origin, evolution, structure and composition of the universe, including the Sun, the stars, and the other celestial bodies. Space based research is being conducted to investigate the structure and dynamics of the Sun and its long- and short-term variations; cosmic ray, x ray, ultraviolet, optical, infrared, and radio emissions from stars, interstellar gas and dust, pulsars,

neutron stars, quasars, black holes and other celestial sources; and the laws governing the interactions and processes occurring in the universe. Many of the phenomena being investigated are not detectable from ground-based observatories because of the obscuring or distorting effects of the Earth's atmosphere.

To achieve the objectives of the Physics and Astronomy program, NASA employs theoretical and laboratory research; aircraft, balloon, and sounding rocket flights; Shuttle/Spacelab flights; and free-flying spacecraft. Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories. The scientific information obtained and the technology developed in this program are made available to the scientific communities to apply to and to advance scientific knowledge, education and technology.

The Physics and Astronomy missions undertaken to date have been extraordinarily successful, and a number of missions continue to produce a rich harvest of scientific data. The International Ultraviolet Explorer (IUE) and the Solar Maximum Mission (SMM) are still operating and new scientific results are continually emerging from the analysis of the High Energy Astronomical Observatories (HEAO) and Infrared Astronomical Satellite (IRAS) data sets.

Hubble Space Telescope

The HST will make a major contribution to understanding the stars and galaxies, the nature and behavior of the gas and dust between them, and the broad question of the origin and scale of the universe. Operating in space above the atmospheric veil surrounding the Earth, the HST will increase by more than a hundredfold the volume of space accessible for observations. With its significant improvements in resolution and precision in light sensitivity and in wavelength coverage, the HST will permit scientists to conduct investigations that could never be carried out using ground-based observatories due to the obscuring and distorting effects of the Earth's atmosphere.

The HST will enhance the ability of astronomers to study radiation in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will record greater detail about the objects under study. It will make possible observation of objects so remote that the light will have taken many billions of years to reach the Earth. As a result, we will be able to look far into the distant past of our universe. The HST will also contribute significantly to the study of the early state of stars and the formation of solar systems, as well as to the observation of such highly-evolved objects as supernova remnants and white dwarf stars. With the HST, we may be able to determine the nature of quasars and the processes by which they emit such enormous amounts of energy, and it may also be possible to determine whether some nearby stars have planetary systems.

The HST will be an automated observatory, delivered into orbit by the space shuttle. Data from its scientific instruments will be transmitted to Earth via the TDRSS. The HST design will permit in-orbit maintenance, repair, and/or retrieval by the Space Shuttle

for return to Earth for required refurbishment and then relaunch by the space shuttle.

During fiscal year 1985, significant progress was made towards completion of the HST development. Almost all major elements of the spacecraft, including the Optical Telescope Assembly, the three flight Fine Guidance Sensors, the Science Instrument Control and Data Handling Unit, and the five Scientific Instruments have been delivered and assembled into the observatory at Lockheed. The Assembly and Verification (A&V) Program of the integrated spacecraft began at Lockheed in fiscal year 1985. HST functional, modal, and electromagnetic compatibility testing have all been successfully completed. These tests verified the overall mechanical, electrical, and structural integrated system design integrity and quality of workmanship. Especially gratifying were the pointing stability test results, which showed performance well within specifications.

In fiscal year 1986, program focus continued on the A&V activities at Lockheed. The Major A&V tests conducted in fiscal year 1986 included acoustic, thermal vacuum, and pre-ship functional tests.

During fiscal year 1987, HST will be actively maintained in the verification and test area at the Lockheed Missiles and Space Company in Sunnyvale, CA. Periodic electrical, mechanical and structural tests will be conducted throughout fiscal year 1987 to assure the integrated spacecraft's continued performance. These additional confidence tests will provide burn-in and maturing of the electronics and will allow detection of subsystem anomalies which might otherwise have occurred early in orbit. Fixes of any anomalies prior to launch will be necessary to assure the reliability and operational efficiency of the HST. The active storage will also allow periodic end-to-end verification of the spacecraft, ground system and communications systems.

Many of the sophisticated HST subsystems, particularly the electromechanical ones in the pointing control system and the science instruments, require constant monitoring and testing to detect deterioration. Maintenance of the spacecraft requires that critical scientific and engineering skills remain available through this active storage period to conduct the tests and correct anomalies.

Gamma Ray Observatory

The objective of the Gamma Ray Observatory (GRO) mission is to measure gamma ray radiation from the universe and to explore the fundamental physical processes powering it. Certain celestial phenomena are accessible only at gamma ray energies. The observational objectives of the GRO are to search for direct evidence of the synthesis of the chemical elements; to observe high energy astrophysical processes occurring in supernovae, neutron stars, and black holes; to locate gamma ray burst sources; to measure the diffuse gamma ray radiation for cosmological evidence of its origin; and to search for unique gamma ray emitting objects.

Cosmic gamma rays represent one of the last frontiers of the electromagnetic spectrum to be explored. The low flux levels of gamma ray quanta, and the high background they produce through their interaction with the Earth's atmosphere, coupled with the demand for better spectral, spatial, and temporal resolution of

source features, combine to require that large gamma ray instruments be flown in space for a prolonged period. Gamma rays provide unique information on the most intriguing astronomical objects yet discovered, including quasars, neutron stars, and black holes. The GRO is scheduled for launch by the space shuttle. The spacecraft is designed to accommodate four large gamma ray instruments and to allow for refueling by the space shuttle. Because of the necessity for long exposures, the spacecraft will be pointed in a fixed direction in space for periods of a few hours up to two weeks at a time.

The magnitude of the STS launch delay has led to the decision to reduce costs by stretching out the instrument delivery schedules by an average of 6 months. Though all hardware fabrication for the four instruments has been completed, instrument assembly and integration will not be completed in the last quarter of fiscal year 1986 as originally planned but, in general, will slip into the first and second quarters of fiscal year 1987. Instrument integration, verification and test will begin for all instruments in fiscal year 1987 and will be completed in early fiscal year 1988. After completion of final calibration in 1988, they will be placed in "active" storage until delivery to TRW for integration and test with the completed spacecraft.

Problems due to the late availability of engineering drawings, and with the structure assembly bolts, were already occurring in the fabrication of the spacecraft structure. These problems resulted in a cost overrun of the prime contract and several months of internal schedule slippage. In addition, these problems, and the decision to avoid unnecessary overtime charges, have caused completion of spacecraft assembly to move to the third quarter of fiscal year 1987. In addition, in fiscal year 1987 all flight mechanical components will be fabricated, the propulsion subsystem assembled, and the flight software validation completed. These activities, together with the rescheduled instrument activities, all support a rescheduled launch readiness date (LRD) of second quarter, fiscal year 1990.

Shuttle Spacelab Payload Development and Mission management

The objectives of Shuttle/Spacelab Payload Development and Mission management are to develop instruments to conduct experiments and acquire new knowledge in the disciplines of physics and astronomy, to develop experiment interface hardware for materials processing, to develop sounding rocket class payloads for flight on the space shuttle, and to manage the mission planning and execution of all NASA Spacelab and attached payloads. This project also supports the development of all physics and astronomy experiments, the system management and engineering development of the flight equipment and software, the payload specialist training and support, the physical integration of the payload with the Spacelab system, the operation of the payloads during flight, the dissemination of data to experimenters, and the analysis of physics and astronomy flight data. In addition, this project funds the mission management efforts for all NASA Spacelab and other attached payloads.

Instruments are currently under development for several Shuttle/Spacelab missions with primary emphasis on physics and astronomy. These instruments are divided into two classes: multiuser instruments and principal investigator instruments. The multiuser instruments are those instruments that have a broad capability, can accommodate a number of principal investigator-furnished instruments, and have a larger user community. The principal investigator instruments are those proposed for a specific scientific investigation by a single investigator who may not have coinvestigators.

Three ultraviolet telescopes were completed and were scheduled for a Shuttle launch in 1986 (Astro-1); however, due to the *Challenger* accident, this mission was not flown. This mission was designed to conduct investigations in ultraviolet imaging, spectrophotometry, and polarimetry at very high resolution.

Work is proceeding on instruments for the Shuttle High Energy Astrophysics Lab (SHEAL). The initial mission, SHEAL-1, will study the celestial soft x-ray background and obtain information on the local interstellar medium. Instruments for a second mission, including a broad band x-ray telescope and an associated two-axis pointing system, are also under development.

Initial instrument development work is under way for Space Plasma Lab (SPL) missions. These missions are being developed to use the Earth's natural plasma environment as a laboratory to study in detail the behavior of plasmas as they are subjected to a variety of perturbances.

As a result of the delays ensuring from the *Challenger* accident, the first Earth Observations Mission (EOM) mission (EOM-1/2) is being cancelled. The second EOM mission is being reconfigured as an Igloo/2-pallet mission, now called ATLAS-1, and will accommodate the EOM-1/2 instruments with some modifications. Mission management continues in support of this reconfiguration, although at a phasedown level.

Explorer

The Explorer program provides the principal means of conducting investigations of stellar physics and of the near-Earth interplanetary environment having limited, specific objectives and not requiring major observatories. Included in the present program are missions to study atmospheric and magnetospheric physics; the several magnetospheric boundaries; interplanetary phenomena; cosmic ray investigations; and x rays, ultraviolet, and infrared astronomy. Studies are conducted to define future high priority science explorer missions. NASA engages in cooperative missions with other Federal agencies and other nations whenever such cooperation will assist in achieving mission objectives.

Work continues in fiscal year 1986 and will continue in fiscal year 1987 on a number of different Explorer programs, one of which is the Cosmic Background Explorer (COBE). The COBE observatory includes three instruments, and the major instrument activities for fiscal year 1987 will consist of completion of rebuilding and testing the flight instruments.

Work on the COBE spacecraft main structure, designed for a shuttle launch, has been temporarily halted. Modifications of the COBE

structure design are now being developed to permit launch on a Delta vehicle as a baseline since a Western Test Range launch is necessary. This redesign will also allow COBE to be launched on other expendable launch vehicles of this class, in the event that a Delta is not available, as well as by the shuttle.

During fiscal year 1987, the major spacecraft efforts will consist of completing the redesign of the spacecraft structure and testing of the spacecraft "black boxes" (e.g., telemetry, control, power, distribution, etc.).

These "black boxes" will be used directly in the Delta configuration with little or no change. The majority of spacecraft subsystems have been delivered and no major problems remain. These subsystems are, for the most part, also directly compatible with the Delta launch vehicle configuration.

The major effort for the German Roentgen Satellite (ROSAT) in fiscal year 1987 will be the design and development of the U.S. operated ROSAT Science Data Center. The High Resolution Imager (HRI), the U.S. science instrument built for the ROSAT Program, has been integrated and tested at the Smithsonian Astrophysical Observatory (SAO) and is ready for shipment in October 1986 to Germany for integration and test with the ROSAT Telescope Focal Instrumentation unit. Following integration in Germany, HRI will be returned to SAO for rework and refurbishment as necessary.

The Combined Release and Radiation Effects Satellite (CRRES) instrument was scheduled for a final integration for launch in the last quarter of fiscal year 1986. Activities have now been essentially put on hold. Revisions to the STS launch plans have resulted in the decision to remove the older detectors from the instrument (due to lifetime problems) and to replace them during fiscal year 1987. The instrument then will be reintegrated and prepared for launch to support the required launch readiness date which will be established in fiscal year 1987.

The Heavy Nuclei Collector mission has been put on hold pending resolution of funding issues. The original plan was to reuse the Long Duration Exposure Facility (LDEF) spacecraft. The revised plan is to build a lightweight, smaller structure which would not require as much space in the Shuttle bay, thereby enhancing manifesting possibilities. Using this small structure and revising orbit and altitude parameters will permit NASA to design a mission which will accomplish all of the scientific goals in a much more cost effective manner.

Extreme Ultraviolet Experiment (EUVE) instrument development, including detector and electronics flight fabrication, is underway at the University of California, Berkeley. The EUVE instrument will perform the first detailed all-sky survey of extreme ultraviolet radiation between 100 and 1,000 angstroms—a hitherto unexplored portion of the electromagnetic spectrum.

During fiscal year 1986, following termination of the Leasecraft investigations, a plan was developed for an EUVE spacecraft using the Solar Maximum Mission Multi-Mission Spacecraft (MMS) design. This reusable new Explorer Platform would sequentially accommodate EUVE, the X-Ray Timing Explorer (XTE), and future Explorer missions not yet defined. The Explorer Platform, with its EUVE science payload, has recently been reconfigured so that it

may launch on either an STS or Delta vehicle. Follow-on missions will be carried up by the Shuttle and changed-out in-orbit. The advantages of this approach include exploitation of the agency resource investment in this proven spacecraft design and its demonstrated reliability, sharing of MMS spares, reduction of STS payload by requirements, use of a proven modular design allowing for in-orbit repairs, and commonality of interfaces to instruments—all of which result in major cost-reduction and cost-avoidance for both the current and future Explorer Program missions.

The Italian *San Marco-D* spacecraft preship review was successfully supported by NASA personnel in July, and activation of the San Marco Launch Facility was underway when the Kenyan Government notified the Italians that transfer of a major portion of the ownership of the launch facilities was necessary before the launch could be permitted. The *San Marco-D* launch is now on indefinite hold pending the results of further Italian/Kenyan negotiations.

Mission operation and data analysis

The purpose of mission operations and data analysis is to conduct operations and to analyze data from the physics and astronomy satellites after launch. This program also supports the continued operation of a number of spacecraft, after their originally planned objectives have been achieved, for purposes of conducting specific investigations that have continuing, high scientific significance. The funding supports the data analysis activities of the many investigators at universities and other research organizations associated with astrophysics and solar terrestrial operational satellite projects. Actual satellite operation, including operation control centers and related data reduction and engineering support activities, is typically carried out under a variety of mission support or center support contracts.

Fiscal year 1987 funds will support continued mission operations and data analysis for the International Ultraviolet Explorer and the Solar Maximum Mission, and continued analysis of the extensive data obtained by the Infrared Astronomical Satellite and the High Energy Astronomy Observatories (HEAO). The fiscal year 1987 funding will support the data analysis and Guest Investigator programs on the HEAO-2 and HEAO-3 missions.

Research and analysis

The research and analysis program provides for the research and technology base necessary to define, plan, and support flight projects. Preliminary studies to define missions and/or payload requirements are conducted, as are theoretical and ground based supporting research and advanced technology development (ATD). Activities included are supporting research and technology (SR&T), ATD, and data analysis.

During fiscal year 1987, the supporting research and technology program will support those tasks that contribute to maintaining a firm base for a viable physics and astronomy program. Emphasis will continue on infrared detector development and on expansion of technology related to large x-ray mirrors, advanced x-ray detectors, gamma ray spectrometers and instrumentation. Emphasis will also

be placed on the development of a large array micro-channel plate, and on intensified charge-coupled imagery devices. In the area of solar physics, activities will support the Solar Maximum Mission, especially through theoretical studies of high energy phenomena. Development of advanced generation instrument concepts will continue, especially for the extreme ultraviolet and x-ray wavelengths and for analyzing the structure and dynamics of the solar interior.

Fiscal year 1987 funding will also continue to support feasibility and definition studies on future potential candidate missions such as the Advanced X-ray Astrophysics Facility (AXAF), Gravity Probe-B mission (GPB), and the Space Infrared Telescope Facility (SIRTF).

In fiscal year 1987, the AXAF Test Mirror Assembly rework will be completed and tested. The industrial Phase B contracts with Lockheed and TRW will be extended to February 1987 to allow completion of studies of the use of space station co-orbiting platform modules, space station servicing, and examination of the compatibility of Space Infrared Telescope Facility requirements with AXAF designs. Definition and technology development for the science instruments will continue in fiscal year 1987 as well.

Progress has been made toward the goal of having SIRTF operational in the 1990's as part of NASA's family of Great Observatories. Scientific investigations for SIRTF were chosen in 1984. Scientific requirements, mission requirements, and preliminary engineering requirements for the free-flying mission have been identified. Scientific instruments are in an early phase of definition study.

In fiscal year 1987, the SIRTF detector technology program and definition studies on the scientific instruments will continue. Also planned is work on key telescope technologies in the area of reliable, moveable mechanisms at cryogenic temperatures. Finally, NASA will perform studies of spacecraft options, such as use of Space Station co-orbiting platform modules and possible use of AXAF modules.

In the GPB program, NASA continues to study the feasibility of testing Einstein's General Theory of Relativity. The GPB experiment will measure the drift of four freely rotating gyroscopes in space. In fiscal year 1987, NASA will continue the GPB definition program. Prototype hardware will be designed and tested, and solutions to complex technical problems will be refined during the First Integrated Systems Test, scheduled for completion in 1988.

Suborbital programs

The suborbital program provides versatile, relatively low cost research tools which use balloons, aircraft, free-flying spacecraft, and the space shuttle in all the space science disciplines, including the study of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a domestic and international cooperative basis.

One of the most innovative suborbital activities is the Spartan program, which consists of low-cost payloads flown as autonomous subsatellites. The Spartan subsatellites are deployed and retrieved by the space shuttle. This program suffered a severe loss when the

Spartan Halley payload was destroyed in the *Challenger* accident of January 28, 1986.

COMMITTEE COMMENTS

With the grounding of the shuttle fleet for at least two years, many of NASA's Physics and Astronomy programs will experience a hiatus or a reduction of activity, the effects of which are likely to be felt throughout the space science community for years to come. Not only will the launches of several major observatories be delayed, but the frequency of the launches of the smaller, more affordable payloads which are especially important to our universities will likely decrease.

During this hiatus, NASA must maximize the yield of its Physics and Astronomy programs so that when space launches resume, these programs are in a position to use effectively and efficiently the launch opportunities. Furthermore, during this hiatus, NASA must be mindful of the role of our university space science programs to our Nation's present and future space science capabilities. To maintain a vital and productive national space science capability during the upcoming period of reduced launch opportunities, NASA is encouraged to involve to the maximum extent possible the university space science community in relevant research and analysis. Likewise, NASA is expected to maximize the opportunities for the university space science community with respect to the Explorer and Suborbital programs. Accordingly, the Committee authorizes the administration's request in the following three programs: Explorer Development (\$56.7 million), Research and Analysis (\$51.1 million), and Suborbital (\$64.4 million).

Because the HST will not be operating in fiscal year 1987, NASA's mission operations budget requirements are accordingly decreased. Therefore, the Committee has reduced its authorization for Mission Operations and Data Analysis by \$47 million below the administration's request. Nevertheless, NASA should continue to conduct mission operations activities for active space science spacecraft, to the maximum extent possible, in addition to conducting to the fullest extent possible its data analysis responsibilities for expired and active spacecraft.

With the delay in the launch of the HST, NASA must store the spacecraft and maintain the science teams associated with the spacecraft. Likewise, NASA will incur similar costs due to the anticipated launch delay of the GRO. Therefore, the Committee authorizes above the administration's requests an additional \$68 million for the HST and an additional \$6 million for the GRO.

The Committee authorizes for Shuttle/Spacelab Payload Development a funding level that is \$32 million below the administration's request. With fewer Shuttle flights in fiscal year 1987 and beyond, there will be fewer flight opportunities for Spacelab missions and for other space science payloads. The Committee expects NASA to accommodate this reduction without adversely affecting NASA's payload development capabilities.

With regard to solar astronomy, the Committee recognizes that this initiative has been a modest but sustained effort since the inception of the space program, characterized over the past 4 years

by the Solar Optical Telescope (SOT) program, whose funding was terminated in the fiscal year 1987 request. Regrettably, budget constraints may limit our national effort in solar astronomy over the next several years, as well. In turn, careful attention should be given to this discipline to ensure that the community of solar scientists are sustained in productive solar research and that a balanced mix of solar astronomy projects are continued within NASA.

To that end, the Committee wishes to call attention to the significance of a solar astronomy effort over the next few years which can encourage innovative research and build a base for solar astronomy in the early 1990's. The Committee notes that the solar physics community has reaffirmed the highest scientific priority for a solar astronomy program and is restructuring the SOT program to reduce the cost while maintaining the crucial scientific elements.

The Committee believes that it is incumbent upon NASA to ensure that human and material investments made in SOT are transferred in an orderly manner to a solar astronomy program tailored to the budgetary and launch constraints in the period of 1987 through the early 1990's. Therefore, the Committee directs NASA to provide the Committee not later than December 31, 1986 a written evaluation of the status of solar astronomical research and a plan to recover the maximum solar science return possible in the aftermath of the elimination of funds for SOT and the disruption of the shuttle manifest by the *Challenger* accident.

LIFE SCIENCES—\$74,300,000

The Committee has authorized \$74.3 million for fiscal year 1987, \$.4 million below the administration's budget request. The Committee expects NASA to treat this as a general reduction to the Life Sciences Program.

The goals of the Life Sciences Program are to provide a sound scientific, medical, and technical basis for safe and effective manned space flight, and to advance the understanding of the basic mechanisms of biological processes by using the unique capabilities of the space program. Results from the research program are applied to: the immediate needs in the maintenance and health of the astronauts; understanding the response of biological systems to weightlessness; the design of advanced life support systems for use on future missions; and understanding the biosphere of the planet Earth, its origin, evolution, and present state.

The Life Sciences Program is the key to developing a capability to sustain a permanent manned presence in space and to utilize the space environment to study living systems. These activities include both ground-based and space research efforts, which are mutually supportive and integrated, and use a composite of disciplines and techniques in both biology and medicine to address space-related medical problems and fundamental biological processes.

Life science flight experiments

The objective of the Life Sciences Flight Experiments Program is to assimilate information and scientific questions from the various life sciences disciplines and to translate them into payloads de-

signed to expand our understanding of the basic physiological mechanisms involved in adapting to weightlessness. The program includes selection, definition, inflight execution, data analysis, and reporting of medical and biological investigations.

Current activities include the development of life sciences flight experiments to be flown on the first dedicated Life Sciences mission, Space Life Sciences-1, (SLS-1) which will concentrate on human investigations. Many of the experiments and associated flight hardware flown on earlier Shuttle flights have supported and enhanced the preparations for SLS-1 and subsequent missions. In addition, experiment development activities are currently underway to support the flight of the first International Microgravity Laboratory-1 (IML-1) mission. Human vestibular experiments, plant investigations, and animal support hardware test and check-out are planned.

The investigations planned for SLS-1 and IML-1 explore the known problems of manned space flight through the use of both human and animal subjects, and also include key investigations in gravitational biology. Principal investigators will examine cardiovascular adaptation, space adaptation syndrome, muscle atrophy, bone demineralization, early anemia in weightlessness, and the effects of weightlessness on plant and animal development. The SLS-1 mission will be unique in several respects: it will be the first Shuttle/Spacelab mission dedicated entirely to life sciences, and it will involve highly skilled scientists as payload specialists, thus permitting the use of numerous experimental procedures never before used in space.

In addition to the preparation and flight of previously selected experiments, increasing activity and emphasis will be directed towards the study and definition of experiments which can be conducted on the space station.

Fiscal year 1987 funding is required to prepare approved experiments and to continue definition and development of new experiments and hardware which will be flown on future Spacelab/Shuttle missions. These include Shuttle middecks, Japanese J mission, the second dedicated life sciences mission (SLS-2), German D-2 mission, IML-2, and SLS-3. The selection of new experiments through the Announcements of Opportunity (AO) is continuing. In addition, increasing activities are planned to support the development of Space Station Life Sciences experiments and complement.

Research and analysis

The research and analysis activity of the Life Sciences Program is concerned with ground-based and preflight research in basic biology and in those medical problem areas that affect manned spaceflight. The program is comprised of five elements: (1) space medicine; (2) advanced life support systems research; (3) gravitational biology; (4) exobiology; and (5) biospheric research.

The Life Sciences Space Medicine Program is responsible for bringing the technology and practice of medicine to bear on solving the problems of sustaining, supporting, and protecting people working in space. The Advanced Life Support Systems Research Program concentrates on enhancing our ability to support long-dura-

tion manned presence in space and on optimizing the productivity of the STS crews.

The Gravitational Biology Program explores the role of gravity in life processes and uses gravity as an environmental tool to investigate fundamental biological questions. The Exobiology program is directed toward furthering our understanding of the origin and evolution of life, and life-related molecules, on Earth and throughout the universe. The Biospheric Research program explores the interaction between the biota and the contemporary environment to develop an understanding of global biogeochemical cycles.

In fiscal year 1987, Life Sciences Research and Analysis activities will support continued efforts in the five program areas described above and will emphasize improved approaches to managing the space adaptation syndrome.

COMMITTEE COMMENT

The Committee's reduction of \$.4 million from the administration's budget request is a general reduction in the Life Sciences Program.

As the Space Station Program progresses, the mission of the Life Sciences Program assumes a higher priority in developing a fundamental understanding of human adaptability to long-duration exposure in space. Toward that end, the Committee urges NASA to assign to future SLS activities, payloads, and missions the priority that is commensurate with their relevance to the development of a permanent presence in space.

PLANETARY EXPLORATION—\$374,300,000

The Committee authorization of \$374.3 million for Planetary Exploration in fiscal year 1986 is \$51.0 million above the administration's request. This additional authorization is achieved by a decrease of \$53.0 million in Mission Operations and Data Analysis and increases of \$77 million to Galileo, \$3 million to Magellan, and \$24 million to Ulysses. Within Planetary Exploration, the Committee makes the following authorizations:

Summary of funding levels, fiscal year 1987

Galileo.....	\$77,000,000
Magellan (VRM).....	69,700,000
Ulysses (ISPM).....	24,000,000
Mars observer (MGCO)	62,900,000
Mission operations and data analysis.....	77,000,000
Research and analysis.....	63,500,000
Total.....	374,300,000

The Planetary Exploration Program encompasses the scientific exploration of the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are: (1) to determine the nature of plants, comets, and asteroids as a means of understanding the origin and evolution of the solar system; (2) to understand better the Earth through comparative studies with the other planets; (3) to understand how the appearance of life in the solar system is related to the chemical history of the solar system; and (4) to provide a scientific basis for the future

use of resources available in near-Earth space. The projects undertaken in the past have been highly successful. The strategy that has been adopted calls for a balanced emphasis on the Earth-like inner planets, the giant gaseous outer planets, and the small bodies (comets and asteroids). Missions to these planetary bodies start at the level of reconnaissance to achieve a fundamental characterization of the bodies, and then proceed to levels of more detailed study.

The reconnaissance phase of inner planet exploration began in the 1960's and has now been completed, although we still know little about the nature of the Venus surface. Mars has provided program focus because of its potential as a site of biological activity. The Viking landings in 1976 carried the exploration of Mars forward to a high level of scientific and technological achievement, thereby setting the stage for the next step of detailed study. Analyses of meteorites and the Moon rock samples returned by Apollo continue to be highly productive, producing new insights into the early history of the inner solar system and revising theoretical concepts. The Pioneer Venus mission is continuing to carry the study of the Earth's nearest planetary neighbor and closest planetary analog beyond the reconnaissance stage to the point where we have characterized the massive cloud-covered atmosphere of Venus and gathered fundamental data about the formation of the planet.

The exploration of the giant outer planets began relatively recently. The Pioneer-10 and -11 missions to Jupiter in 1973 and 1974 were followed by the Voyager-1 and -2 spacecraft encounters in 1979. Voyager-1 then encountered Saturn in November 1980 and Voyager-2 did the same in August 1981. The Voyager data on these planets, their satellites, and their rings have revolutionized our concepts of the formation and evolution of the solar system. Now, the Pioneer-10 and -11 and Voyager-1 spacecraft are on escape trajectories from the solar system and will continue to return scientific data about the outer reaches of the solar system. The Voyager-2 spacecraft encountered Uranus in January 1986 and has provided our first look at this giant outer planet. In the course of the Uranus encounter, Voyager discovered 10 new Uranus moons. Its trajectory will now carry the spacecraft on to Neptune in 1989.

Prior to the January 1986 *Challenger* accident, the Galileo orbiter/probe mission had been scheduled for a launch to Jupiter in May 1986 by the Space Shuttle, using a Centaur upper stage. Due to the uncertainty of when the shuttle will resume flight operations, and due to the cancellation of the Shuttle/Centaur upper stage program, a launch date and the means of launch have not been determined. The comprehensive science payload is expected to extend our knowledge of Jupiter and its system of satellites well beyond the profound discoveries of the Voyager and Pioneer missions. During 22 months of operation in the Jovian system, Galileo will inject an instrumented probe into Jupiter's atmosphere to make direct analyses, which the orbiter will have the capability to make as many as ten close encounters with the Galilean satellites.

The mission plan includes an option for an encounter with the asteroid Amphitrite, a large (200 km) main-belt asteroid. The decision to implement the option will be made after launch, based upon

an assessment of the health and operational capability of the spacecraft.

Magellan (Venus Radar Mapper)

The Magellan mission will provide global maps of the cloud-shrouded surface of Venus. Using a synthetic aperture radar, Magellan will achieve a resolution sufficient to identify small-scale features and to address fundamental questions regarding the origin and evolution of the planet. Magellan will also obtain altimetric and gravity data to determine the gravity field, internal stresses, and density variations of the planet's interior. This data will be analyzed so that the evolutionary history of Venus can be compared with that of the Earth. Prior to the *Challenger* accident, Magellan was scheduled for Shuttle/Centaur launch in 1988. Decisions related to the date of launch and means of launch are pending.

During fiscal year 1986, major activities will include completion of the design effort for the spacecraft, the radar instrument, and the mission operations system, and the initiation of construction of the flight hardware. The major flight spacecraft subassemblies will be completed and delivered to the spacecraft contractor.

Fiscal year 1987 funds will provide for completion of the radar sensor and for the assembly, integration, and testing of the spacecraft system. The development of the mission operations system will continue.

Ulysses (Formerly International Solar Polar Mission)

Ulysses is a joint NASA and European Space Agency ESA endeavor that will fly a package of experiments to investigate the Sun at high solar latitudes, which cannot be studied from the Earth's orbit. Ulysses, which will provide data on the effects of solar activity on the Earth, was scheduled to be launched in 1986 on the Shuttle/Centaur upper stage. With the cancellation of the Shuttle/Centaur, the launch of Ulysses is postponed pending a decision on launch options.

ESA will provide the spacecraft and some instrumentation and the United States will provide the remainder of the instrumentation, the launch, tracking support, and the radioactive thermal power generators. The mission is designed to obtain the first view of the Sun above and below the plane in which the planets orbit the Sun. The mission will study the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, thereby providing a better understanding of solar activity on the Earth's weather and climate.

The Ulysses mission was restructured in fiscal year 1981, from a two-spacecraft mission—one provided by the United States and one provided by ESA—to a single ESA spacecraft mission. The United States participation in the program remains substantial, however. NASA is developing five of the nine principal investigator instruments and three of the four European investigations have U.S. co-investigators.

During fiscal year 1983, the U.S. flight instruments were delivered to the ESA spacecraft developer for integration and system

testing. All spacecraft testing has been completed, and the spacecraft is being partially disassembled for storage until launch.

Mars Observer Mission (formerly Mars Geoscience/Climatology Orbiter)

The Mars Observer Mission is the first planetary mission utilizing a new approach to low-cost inner solar system mission exploration. This approach, which was recommended by the Solar System Exploration Committee, starts with a well defined and focused science objective and makes use of high-inheritance, modified production/line Earth-orbital spacecraft. The objective of the Mars Observer Mission is to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, atmosphere structure and circulation, topography, figure, gravity and magnetic fields of Mars to find volatile reservoirs and to characterize their interaction with the Martian environment.

The Mars Observer Mission is scheduled to be launched in 1990 using the Space Shuttle and will be inserted into Martian orbit in 1991 to perform geochemical, geophysical, and climatological mapping of the planet over a period of 1 Martian year, which is approximately 2 Earth years. A Transfer Orbital Stage upper stage has been selected to deploy the Mars Observer spacecraft from the shuttle.

In fiscal year 1986, critical design reviews will be held for the instruments, as will the preliminary design review for the spacecraft. In addition, detailed design and fabrication of the spacecraft and instrument hardware will be initiated.

The 1987 funding is required for continuation of major fabrication efforts on both the instruments and the spacecraft, and for preparation for the critical design reviews for the flight system. NASA will complete preliminary design reviews for all the instruments as well as for the mission operations development.

Mission operations and data analysis

The objectives of mission operations and data analysis are in-flight operation of planetary spacecraft and the analysis of data from these missions. Currently, two major classes of planetary spacecraft are operating—the Pioneer and the Voyager spacecraft.

The two Voyager spacecraft are now traveling through the outer solar system on trajectories that will take them into interstellar space. Voyager 1 continues to provide data on the interplanetary medium in that distant part of the solar system. In January 1986, Voyager 2 made a close flyby to the planet Uranus, the first time this planet has ever been visited by a spacecraft. The observatory phase of this encounter, which began in November 1985, will include detailed observations of the planet, its rings, and moons. After the Uranus encounter is completed, the spacecraft will continue on to the planet Neptune, where, in 1989, it will provide us with our first close look at this distant planet.

Pioneers 10 and 11 will continue to explore the outermost solar system. Pioneer 10 will soon enter the unexplored region beyond Pluto where the Sun's influence is secondary to those of true interstellar space. These spacecraft will continue the search for gravitational evidence of a tenth planet. Pioneers 6-9 are still collecting

information on the interplanetary magnetic field and solar wind as they orbit the Sun. In 1986, these spacecraft were used to observe Comet Halley as it passed in their vicinity.

The Pioneer Venus orbiter continues to obtain data from Venus' atmosphere and magnetosphere. In late 1985, the spacecraft spin axis was adjusted to allow ultraviolet observations of Comet Halley. The Pioneer Venus is the only spacecraft able to observe the Comet at its closest approach to the Sun and provided critical additions to data that was gathered by foreign spacecraft that made observations at other points in the Comet's orbit.

Fiscal year 1986 funding is required for the continued operation and data analysis activities in support of the Voyager and Pioneer operations, as well as for the extension of the Voyager 2 mission to a 1989 encounter with the planet Neptune.

Research and analysis

The research and analysis program contains four elements required to: (1) assure that data and samples returned from flight missions are fully exploited; (2) undertake complementary laboratory and theoretical efforts; (3) define science rationale and develop required technology to undertake future planetary missions; and (4) coordinate an International Halley's Comet Watch and provide coinvestigator support to the European Space Agency's Giotto Mission to Halley's Comet.

The fiscal year 1987 Halley's Comet Co-Investigations and Watch funding is required to continue support of U.S. coinvestigators involved in the European Space Agency's Giotto mission who will be analyzing the data acquired from Halley's Comet flyby of Earth. The fiscal year 1987 funding is also required to continue operations of both the Infrared Telescope Facility on Mauna Kea, Hawaii, and the Lunar Curatorial Facility.

COMMITTEE COMMENTS

The U.S. solar system exploration program is at a critical juncture following the *Challenger* accident. Not only did the Galileo and Ulysses missions, both scheduled for May 1986 launches, miss their 1986 launch opportunities, but they must now be reconfigured to accommodate a new, yet-to-be-determined means of launch, following the cancellation of the Shuttle/Centaur Program. The launches of these two missions could be delayed as much as 4 to 5 years. These delays will have serious consequences for our Nation's solar system research capabilities and could create particular hardships for the related space research and educational activities performed at universities.

With neither Galileo nor Ulysses in operation during fiscal year 1987, NASA's will have few, if any, requirements for mission operations related to either of these missions. Therefore, the Committee has recommended a reduction in Mission Operations and Data Analysis of \$53 million. The Committee notes, however, that productive and meaningful data analysis can still be performed on the ongoing Voyager and Pioneer missions and on missions that have expired. Therefore, the Committee expects NASA to conduct the

maximum amount of data analysis that can still be performed within the Mission Operations and Data Analysis budget.

With the delay in the launch of both Galileo and Ulysses, NASA will have to store the Galileo spacecraft and will have to maintain the science teams associated with these two missions. Therefore, the Committee recommends an additional authorization of \$77 million to the Galileo Program and an additional \$24 million to the Ulysses program.

Also, during this period of sustaining engineering support for Galileo, the Committee encourages NASA to focus its in-house design and engineering talents on design and advanced technology efforts required for the Mariner Mark II missions, which are essential to the future of the solar system exploration program.

The Committee is greatly concerned over reports that NASA is considering delaying the launch of the Mars Observer spacecraft beyond the previously scheduled launch date of August 1990. Because the Mars Observer launch opportunity occurs only every 2 years, the next earliest launch opportunity would occur in late 1992. With the uncertainties associated with the Galileo, Ulysses, and Magellan missions, the Committee believes that it is important that NASA maintain as closely as possible the launch schedule for the one current planetary mission that was not directly affected by the Challenger accident.

Also, that the Mars Observer mission is the first of the Planetary Observer missions further underscores the importance of this mission and a timely launch date. Finally, the international implications of this mission should not be overlooked. The Soviet Union intends to launch in 1988 its mission to the Mars moon Phobos, and in the early 1990's, its Vesta asteroid mission may also deploy two landers to the Martian surface. By delaying the Mars Observer mission to 1992, the United States will have ceded Mars to the Soviet Union and will have reduced significantly any opportunities for international cooperation related to these Mars missions.

Therefore, the Committee is unable to support a Mars Observer launch that occurs any later than August 1990. Furthermore, the Committee expects to be notified immediately if there is any change in the launch date of the Mars Observer mission from August 1990, along with the reasons supporting that change.

With the anticipated delay in the launch of Galileo and with the likelihood that the Magellan mission will be launched before Galileo, the Magellan Program has borrowed extra radar equipment from the Galileo Program to use as a backup for the Magellan mission. To allow the Magellan Program to pay back the Galileo Program for this radar equipment, the Committee authorizes an additional \$3 million for the Magellan Program.

During this "standdown" period which our space program faces for the next few years, research groups within NASA and in our Nation's universities and space industry research laboratories face the unfortunate prospect of fewer planetary science opportunities. The Committee notes the importance of the university space research programs to our national space infrastructure and believes that these university space research programs should continue to perform productive and meaningful research during this period. Therefore, the Committee authorizes the full administration re-

quest of \$63.5 million for Planetary Exploration Research and Analysis.

SOLID EARTH OBSERVATIONS—\$74,1000,000

The Committee authorization of \$74.1 million is identical to the administration's request.

The objectives of the Solid Earth Observations Program are to understand the processes controlling the state of the land surface and the interior of the Earth as well as the interaction of the solid Earth with the atmosphere and the oceans. The Solid Earth Observations Program is an integral part of the overall NASA Earth Science and Applications effort to increase our understanding of the planet Earth through the study of its dynamics, the physical processes which affect its habitability, and its solar terrestrial environment.

The objective of the Shuttle/Spacelab payload development project is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for land remote sensing research. The Shuttle Imaging Radar (SIR), which was flown on the Shuttle in October 1984, has demonstrated the utility of spaceborne imaging radar for geologic exploration. The Large Format Camera, required for high resolution mapping, was flown successfully on the Shuttle in 1984 and is presently under consideration for possible commercialization upon completion of the R&D phase. The next generation SIR, involving use of SIR-B components and multipolarized, dual frequency instruments, is under development for flight in the early 1990's.

Fiscal year 1987 funding supports preparations for reflight of the Large Format Camera and the SIR-B, plus data analysis. Fiscal year 1987 funding will also continue development of the Shuttle Imaging Spectrometer Experiment.

The geodynamics program research objectives include determination of the movements and deformation of the Earth's crust; the processes which drive tectonic plates; the rotational dynamics of the Earth and its interactions with the atmosphere and oceans; the Earth's gravity and magnetic fields; and the interior movements and Earth orientation over an extended period, along with accurate knowledge of the variability of the Earth's geopotential fields.

The major objectives of the Solid Earth Research and Analysis Program are to characterize the physical, geological and biological state of the Earth's surface, to explore its variation with time, and to understand the processes which control its state and its interactions with the atmospheric and hydrologic systems.

COMMITTEE COMMENTS

The Land Remote-Sensing Commercialization Act of 1984 (Public Law 98-365) directs NASA to continue and enhance remote sensing research and development programs. The Committee, in developing the act, intended for NASA's continued role in remote sensing to provide for continued U.S. leadership in the development of remote sensing technologies and applications. In 1984, NOAA's Landsat system was the world's only land remote sensing system, but the

Committee was concerned that development of systems by other nations would threaten U.S. leadership in this field.

The Committee finds that the emergence of foreign remote sensing systems, notably the French SPOT system, and the uncertain status of Landsat commercialization has increased the threat to U.S. leadership in remote sensing. The Committee believes that NASA's role in remote sensing research and development will be critically important to the competitiveness of future U.S. remote sensing systems and to the development of commercial applications by data users.

NASA's role, as prescribed by Public Law 98-365, is to perform research and development to develop remote sensing instruments which will be technologically competitive in serving the needs of data users. This requires NASA to work closely with data users, both Federal and private, to develop new data applications. The act directs NASA to work with users and to make available experimental data sets for federally funded and cooperative research projects. To protect the data marketing of the commercial Landsat operator, however, the act requires that dissemination of experimental data not be in competition with private sector activities. The Committee is aware that this restriction inhibits NASA's ability to make available experimental data for research and user evaluation.

The Committee directs NASA to report by February 1, 1987, on recent accomplishments in remote sensing research and development and on NASA's plans for future research and development programs. The report shall include an evaluation of the remote sensing instruments which can be developed in the foreseeable future and the applications which will contribute most significantly to the productive use of remote sensing data. The report also shall include a description of NASA's policies pursuant to the experimental data dissemination restrictions in Public Law 98-365 and a discussion of the act's effect on NASA's ability to obtain from data users, evaluations of experimental data sets, along with any policy recommendations.

Also, the Committee believes that gaining a better understanding of our planet as an integrated system is an essential element in our space policy. Space observation of global weather, climate, ocean, and land processes offers unique opportunities for expanding our knowledge and understanding of global change. The Committee directs NASA, working with NOAA, the National Science Foundation (NSF), and the U.S. Geological Survey (USGS), to prepare and present to the Committee by June 1, 1987 a study on the feasibility and advisability of establishing a formal Earth System Science Program to include the establishment of a National Institute for Earth Systems Science Studies, jointly supported by NASA, NOAA, NSF, and the USGS, for the purpose of initiating a long-term research program to study the Earth, its components, and its processes.

The study should address the following issues:

- (1) The utility of global observations and measurements from space in understanding the physical, chemical, and biological processes responsible for these Earth system changes;
- (2) The need for developing a coordinated information system to monitor and record changes in the Earth systems, predict or

anticipate future global trends, and provide global information for Earth resources;

(3) The extent to which space observations of global weather and climatic conditions, ocean composition, and land condition offer opportunities for expanding our knowledge and understanding of global change;

(4) The need for and advisability of establishing a comprehensive federally supported research program for studying Earth system science to gain knowledge and understanding for guiding national and international policy; and

(5) The need for interdisciplinary Federal research and cooperation in global studies of the Earth, and the goals and missions of NASA, NOAA, NSF, and the USGS in Earth system science research.

The study is to be conducted on the assumption that the Institute would provide the tools and resources for cooperative Federal research studies of global system processes, and would involve the collocation of skilled scientific staff with broad and varied disciplinary expertise, access to adequate computer processing capabilities, advanced information systems, and data reproduction and distribution facilities.

The study should describe the Institute's potential contributions in laying a foundation for a long-term cooperative Federal research program; initiating and developing advanced information systems for accessing, processing, and analyzing the massive amounts of data currently available in existing Earth science and remote sensing data archives; coordinating efforts between the leading civilian Earth science organizations including but not limited to NASA, NOAA, NSF and the USGS; and encouraging international involvement.

The National Institute for Earth Systems Science Studies would be one of several scientific facilities participating in the research program, and would provide a cooperative Federal focal point for contributions to the overall program and would serve as a primary hub of the large integrated data and information system needed by the program.

ENVIRONMENTAL OBSERVATIONS—\$313,900,000

The Committee recommendation for Environmental Observations, \$313.9 million, is \$54 million below the administration's request of \$367.9 million. Within Environmental Observations, the Committee makes the following authorizations:

	<i>Millions</i>
Scatterometer.....	\$30.9
Upper Atmosphere Research Satellite (UARS).....	113.2
Ocean Topography Experiment (TOPEX).....	19.0

The objectives of NASA's Environmental Observations Program are to improve the understanding of processes in the magnetosphere, atmosphere, and the oceans; to provide space observations of parameters involved in these processes; and to extend our ability to predict environmental phenomena, both short and long term, and their interaction with human activities. Because many of these phenomena are global or regional, they can be best, and sometimes

solely, studied from space. NASA's program includes scientific research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites provide a unique view of the radiative, chemical, plasma acceleration, and dynamic processes occurring in the magnetosphere, atmosphere, and oceans.

To achieve these goals, a number of significant objectives have been established for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; optimizing the use of space-derived measurements in understanding large scale weather patterns; advancing our knowledge of severe storms and forecasting capabilities, ocean productivity, circulation, and air-to-sea interactions; improving the knowledge of seasonal climate variability leading to a long-term strategy for climate observation and prediction; and enabling a comprehensive understanding of the solar terrestrial processes and a detailed determination of the physics and coupling between the solar wind, magnetosphere, ionosphere, and the atmosphere.

Upper atmosphere research and analysis

The upper atmosphere research program is a comprehensive research and technology effort designed to investigate and monitor the phenomena of the upper atmosphere and related phenomena in the lower atmosphere. It is aimed at improving our basic scientific understanding of the global atmosphere and the methods needed to assess its susceptibility to significant chemical and physical change. The program's three major thrusts are in the areas of upper atmospheric research, stratospheric processes research, and tropospheric chemistry research.

Recent developments in our understanding of the ozone layer have revealed a possible nonlinear dependence of ozone depletion on the amount of fluorocarbon released to the atmosphere. These findings increase the urgency of the need to verify the completeness and accuracy of the theoretical stratospheric models. In fiscal year 1987, NASA will continue to test the models by means of field measurements, model calculations, and interpretation of satellite data. NASA will continue to develop more realistic two- and three-dimensional models. NASA will also analyze the global data sets from past and present satellites analyzed in fiscal year 1987 to aid in the understanding of large-scale atmospheric processes.

NASA will continue to compare balloon, aircraft, and ground-based measurements in fiscal year 1987 to ensure the validity of the different techniques and to observe chemical species in the stratosphere and troposphere to determine the exchange of gases between the lower and upper atmosphere. These balloon and aircraft measurement programs are the only way to measure many of the localized phenomena of the atmosphere; they also help to validate satellite observations. NASA will also conduct studies of potential new instruments for use on future satellites and suborbital measurement platforms in fiscal year 1987 to ensure that new tech-

nologies are used in improving the capability and cost efficiency of tropospheric composition and upper atmosphere measurements.

Atmospheric dynamics and radiation research and analysis

Fiscal year 1987 funding for Atmospheric Dynamics and Radiation Research and Analysis is required to conduct aircraft flights to study the detail of flows around thunderstorms and fronts, continue comparison of models, study atmospheric scale interactions, and develop techniques to display model outputs in three dimensions. In fiscal year 1987 three major interagency field experiments will significantly improve our understanding of the atmosphere for air and ocean interaction which generate crippling New England snowstorms (GALE), the physics of small strong downdrafts called microbursts which are on the scale of tornadoes (MIST), and the mechanism, of regional precipitation quantification (SPACE) through space, aircraft, radar balloon, and surface-based observations. Other activities will involve continued retrieval and archiving of global International Satellite Cloud Climatology Project data sets, analysis of data from the Earth Radiation Budget Experiment and the Stratospheric Aerosol and Gas Experiment, and continued ground-based and rocket flight support for solar irradiance monitoring. Technology development of active temperature, pressure, and moisture sounders as well as basic lidar technology development will also be continued in fiscal year 1987.

Oceanic processes research and analysis

In fiscal year 1986, Oceanic Processes Research and Analysis activities will include planning to implement the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean and Global Atmosphere (TOGA) program, as well as the development of numerical models and associated data assimilation techniques to determine the general circulation of the oceans. In biological oceanography, NASA will continue to analyze data from Nimbus-7 to estimate global ocean productivity, as well as to help with the conceptual design of the Global Flux Experiment. In addition, NASA will perform accommodation studies for potential flights, of an Ocean Color Imager for the NOAA-K spacecraft. In polar oceanography, NASA will emphasize experimental design for the Program for International Polar Oceans Research, which is planned to involve direct reception of Alaska Synthetic Aperture Radar data from the European Space Agency's ERS-1 and from the Japanese JERS-1 spacecraft due for launch between 1989-91.

The transition of the Pilot Ocean Data System from a technical demonstration to a scientific support facility was completed in fiscal year 1986. Coordination activities with the Office of Naval Research, NSF, and NOAA will be pursued in order to assure that appropriate competing facilities and data archives will be available for the utilization of spaceborne observations from ocean research missions planned within the next decade.

Space physics research and analysis

During fiscal year 1987, NASA will continue its Space Physics Research and Analysis activities with particular emphasis on the analysis of data from the 1986 PROMIS campaign, and from the

International Cometary Explorer's (ICE), which collected unique data in the Earth's distant magnetotail before going on the encounter comet Giacobini-Zinner in September 1985. NASA will continue definition studies during fiscal year 1987 on such missions as the potential cooperative solar terrestrial research with the Japanese and Europeans, follow-on missions for the United States-Italian Tethered Satellite System, and the chemical release investigations in support to the Combined Chemical Release and Radiation Effects Satellite, which is being developed by DOD.

Payload and instrument development

In fiscal year 1987, funding will continue to support the Measurement of Air Pollution from Satellites (MAPS) program, the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) instrument, and the Active Cavity Radiometer (ACR).

Development activities will continue on the international (United States and French) Light Detection and Ranging (LIDAR) instrumentation following completion of conceptual definition, breadboard laboratory activities, and preliminary design reviews. In this advanced state of the technology program, both NASA and the French are supplying science knowledge and hardware to demonstrate first time detail measurements of the atmosphere to aid in forecasting.

In fiscal year 1987, NASA will begin the Solar Terrestrial Instrument Development with increased focus on continued activities with the Japanese Institute for Space and Astronautical Sciences (ISAS) for a mission to explore the Earth's geotail. While ISAS will provide the Geotail Spacecraft and the majority of the instruments, NASA will provide unique instruments to measure the hot, low density plasmas, energetic plasmas, low intensity waves, and weak magnetic fields in the deep magnetic tail. In addition, the ESA and NASA will continue planning a joint solar terrestrial research effort to make detailed measurements of solar variability and solar oscillations, the origin and flow of the solar wind, the interaction of the solar wind with the terrestrial magnetosphere, and the resultant space plasma microprocesses. ESA will provide the SOHO and CLUSTER satellites, and the majority of the instruments. NASA will provide instruments for solar oscillations and solar corona measurements and several unique space plasma instruments.

Extended mission operations

Fiscal year 1987 funding for Extended Mission Operations is required to support continuing missions operations and data analysis for the International Sun-Earth Explorers, the Interplanetary Monitoring Platform, and the Dynamics Explorers. NASA will continue to support the Active Magnetospheric Particle Tracer Explorer, which was launched in 1984. NASA will continue operation of the Nimbus and SME satellites and processing of the collected data, as will activities to provide ground truth for a NASA-developed ozone instrument to be flown on a NOAA weather satellite. The SME and Nimbus satellites continue to produce extremely valuable data on ozone concentrations which will be used to estimate the occurrence of natural variations, sea surface temperatures, aerosol measurements, and ocean productivity. Correlative ground truth

activities will also be continued in fiscal year 1987; these in situ observations are needed to verify the quality of remote observations and improve our ability to interpret them. In addition, fiscal year 1986 funding is required for operating the Earth Radiation Budget Experiment Satellite (ERBE) instruments, payloads, and data set processing and analysis that will occur as the third set of instruments is launched on NOAA-G.

Interdisciplinary research

In fiscal year 1987, NASA will continue interdisciplinary studies with emphasis on integrating research in Oceanic Processes, Atmospheric Dynamics and Radiation, Upper Atmosphere/Troposphere Chemistry, and Land Processes into a unified program to help increase our understanding of global processes. NASA will emphasize specific pilot studies such as those understanding the biogeochemical processes controlling the concentration of atmospheric methane, characterizing changes in properties of the land surface and their effect on climate, and understanding the role of the oceans in the global carbon cycle.

Tethered satellite payloads

The TSS is an international cooperative project with the Italian Government. The United States is developing the tether deployment and retrieval system and is responsible for overall project management and system integration, for development and integration of the instruments, and for the shuttle flight. Italy is developing the satellite and is responsible for development and integration of European investigations. An announcement of opportunity for investigations was issued in April 1984. Selection of investigators was completed in late 1985 and instrument design was initiated in early 1986.

The Italians are experiencing some program delays in the development of the satellite, and the launch schedule is being reevaluated.

The fiscal year 1987 funding is required for final preparations and data analysis activities associated with the scientific instruments on the TSS.

Scatterometer

NASA began design and development activities in fiscal year 1985 on the Scatterometer, which will be flown on the Navy Remote Ocean Sensing System (N-ROSS) in mid-1990 to acquire global ocean data for operational and research usage by both the military and civil sectors.

An announcement of opportunity for specific research investigations using Scatterometer data was released in fiscal year 1985. Contracts were added for the antennas and traveling wave tubes. In November 1985, a preliminary design review was conducted and the announcement of opportunity selection process was completed in February 1986, with the selection of 14 scientific teams.

In fiscal year 1987, design and development of the Scatterometer will be continued, leading to the scheduled launch in mid-1990. In particular, the antenna and traveling wave tube fabrication will be continued, fabrication of the radio frequency subsystem will be ini-

tiated, procurement of a ground-based computer system will be undertaken, and a critical design review will be completed.

Upper Atmosphere Research Satellite Program

The Upper Atmosphere Research Satellite (UARS) will place a set of instruments in Earth orbit which will make a comprehensive measurement of the state of the stratosphere, providing data about the Earth's upper atmosphere in spatial and temporal dimensions which are presently unattainable. Detailed definition studies of the instruments have been completed, and the design and development activities have begun.

The fiscal year 1987 funds are required to continue the design and development of the UARS instruments including flight hardware fabrication, instrument assembly, and environmental testing. In addition, the spacecraft designed and developed activities will be continued in fiscal year 1987.

The ground data handling facility will enable a higher level of interaction among experimenters and theoreticians than has existed with past programs. Implementation of this concept requires that the system be developed on a timely parallel path with the flight hardware so that individual experiment data processing subsystems, including algorithms and the interactive data base, provide maximum interaction and effectiveness in the design and development phase of the program and are fully verified at launch time. To achieve this, fiscal year 1987 funding is required to continue design and development of the ground data handling facility, including hardware delivery and checkout, software preliminary and critical design reviews, science team support, and science algorithm development.

Ocean Topography Experiment

The goal of the Ocean Topography Experiment (TOPEX) is to use satellite radar altimetry to measure the surface topography of the global oceans over a period of three years with sufficient accuracy and precision to enhance our understanding of the oceans' general circulation and its mesoscale variability. The capability of satellite altimetry to address this goal was demonstrated in 1978 by NASA's highly successfully Seasat Program. Such information is needed to understand better how the atmosphere drives the circulation of the oceans, how the oceans in turn influence the atmosphere and, ultimately, the role of the oceans in climate.

Current plans call for NASA and the French Space Agency (CNES) to collaborate on TOPEX to exploit the scientific value of the data. In exchange for this scientific collaboration and the flight of a French altimeter and tracking system, CNES will launch TOPEX in mid-1991 using Ariane. TOPEX is also being planned in concert with the World Ocean Circulation Experiment (WOCE), a major international oceanographic field program being planned under the auspices of the World Climate Research Program (WCRP). WOCE will combine satellite observations from TOPEX with traditional in situ observations to make the first comprehensive determination of the three dimensional current structure of the global oceans. When further combined with ocean surface winds from the NASA Scatterometer planned for flight on the U.S.

Navy Remote Ocean Sensing System (N-ROSS) in mid-1990, NASA will have obtained unique measurements of the oceans' driving force and the resulting ocean response.

In July 1986, NASA issued a Request for proposals to select a single satellite contractor and an announcement of opportunity to select a science working team. Once these selections have been made, NASA will be in a position to initiate full scale development of TOPEX, thus permitting a 1991 launch. The resulting high degree of overlap with N-ROSS and WOCE will permit a truly unique set of coordinated spaceborne and in situ observations to be obtained.

In fiscal year 1987 detailed design work in all areas of the project—satellite, sensors, ground data system, etc.—will be focused on preparing for a critical design review in early 1988 so that hardware fabrication can be initiated.

COMMITTEE COMMENTS

The Committee commends the administration for approving the Ocean Topography Experiment (TOPEX) as a "new-start" in fiscal year 1987. The Committee believes that this cooperative venture with France should not only enhance the standing of the United States in the international scientific community but also substantially assist our understanding of global ocean dynamics. The Committee's authorization of \$19 million for TOPEX does not indicate a lack of support for the program; the purpose of the reduction is to spread the costs of the *Challenger* accident. Also this reduction should not, in and of itself, affect the scheduled launch date of mid-1991 on the French Ariane vehicle.

The Committee has authorized \$113.2 million for the Upper Atmosphere Research Satellite (UARS) program, a funding level that is \$39 million below the administration's request of \$152.2 million. With a shuttle downtime of 2 years, at a minimum, the scheduled launch date of the UARS has now slipped from late 1989 to late 1991. This 2-year delay in the launch of UARS will permit a reduction of this magnitude without disturbing the overall goals and objectives of the program.

Finally, the Committee's authorization for the Scatterometer, \$30.9 million, is \$5 million below the administration's budget request. The intent of this reduction is to assist in the distribution of costs associated with the *Challenger* accident, and the Committee believes that the Scatterometer still will be completed in time for the scheduled launch on the Navy Remote Ocean Sensing Satellite (N-ROSS) in mid-1990.

MATERIALS PROCESSING IN SPACE—\$43,900,000

The Committee authorization of \$43,900,000 for Material Processing in Space for fiscal year 1987 is identical to the administration's request.

The Materials Processing in Space Program emphasizes the science and technology of processing materials to understand constraints imposed by gravitational forces and the unique capabilities made possible by controlling these processes in the space environment. Ground-based research, technology development, and pay-

load definition in fiscal year 1986 are being concentrated on six major processing areas: metals and alloys, electronic material, glass and ceramics, biotechnology, combustion, and fluid dynamics and transport phenomena. These activities will provide the scientific basis for future space applications of materials processing technology as well as provide a better understanding of how these processes occur on the ground. Definition studies will be performed for Shuttle experiment candidates in areas such as containerless experiments, combustion science, solidification and crystal growth, and blood storage. Also included are experiments in drop tubes, towers, and aircraft. Studies and science support for joint endeavor and technical exchange agreements are included in this program.

Materials Experiment Operations support a range of scientific and commercial experiments in the Microgravity Science and Application Program. These include shuttle middeck experiments, the Materials Experiment Assembly, and the Materials Science Laboratory, which is carried in the orbiter bay. These capabilities will enable users to develop cost-effective experiments and will allow a better understanding of the technical risks associated with different experiments before attempting to develop more complex hardware. In addition, reflight of investigations on Shuttle/Spacelab missions and the middeck is provided for in Material Experiment Operations.

Fiscal year 1987 funding will support, among other things, the centers for bioprocessing research located at the University of Arizona and the University City Science Center in Philadelphia, PA, as well as the Microgravity Materials Science Laboratory at the Lewis Research Center.

COMMITTEE COMMENTS

The Committee continues to support the Materials Processing in Space Program as a necessary precursor to the technological and commercial exploitation of the microgravity environment of space. The Committee also notes that insufficient budgetary resources and manifest priorities are issues which continue to affect the progress of this program. If the United States is to maximize the technological and commercial potential of the space station as soon as it is operational, as well as that of other space-related initiatives, a sufficient scientific data base for future space applications must be generated in a timely manner. For this reason, the Committee has authorized the full budget request of \$43.9 million for materials processing in space for fiscal year 1987.

The Committee notes with approval NASA's programmatic decision to use the shuttle downtime to modernize its microgravity related apparatus and equipment. This effective use of resources should enable a more productive and reliable Materials Processing in Space Program when shuttle flights resume and should facilitate the technological and commercial development of space.

COMMUNICATIONS—\$104,500,000

The Committee authorizes \$104.5 million for fiscal year 1987 in lieu of the administration's request of \$19.5 million and specifically

authorizes \$85 million for the Advanced Communications Technology Satellite Program.

Summary of funding levels, fiscal year 1987

Advanced Communications Technology Satellite (ACTS).....	\$80,000,000
Research and analysis.....	14,000,000
Search and rescue.....	1,100,000
Technical consultation and support studies	3,200,000
Experiment coordination and operations support.....	1,300,000
Total.....	104,500,000

Advanced Communications Technology Satellite

The objective of NASA's Advanced Communications Technology Satellite (ACTS) Program is to prove the feasibility of certain advanced communications technologies through a flight test program.

The specific technologies to be validated include: (a) the use of multiple fixed and scanning spot antenna beams; (b) frequency reuse; (c) beam interconnectivity at both intermediate frequencies and at baseband; (d) advanced system network concepts; and (e) dynamic rain-compensation techniques. These technologies will apply to a wide range of communications systems in the 1990's. A contract was signed in August 1984 with RCA to develop the flight and ground hardware. TRW, Comsat, Motorola, Electromagnetic Sciences, Hughes, and other manufacturers are major subcontractors.

The ACTS spacecraft will be launched from the shuttle into geostationary orbit. The spacecraft will consist of a commercial communications package, including a multibeam antenna, baseband processor, RF matrix switch, traveling wave tube amplifier, and low noise receiver. The ground segment will consist of a NASA ground station and a master control station. Following launch and checkout, a 2-year program of user-funded experiments will be initiated during which time ACTS system technologies will be tested, evaluated, and validated. To date, over 80 organizations, including DOD, have requested consideration for over 118 experiment opportunities on ACTS.

Research and analysis

The Communications Research and Analysis Program continues to develop component and device technology required by NASA, other government agencies, and U.S. industry for advanced communications satellite systems. Big payoff items leading to greater spectrum and bandwidth efficiency are being pursued. In addition, the mobile communications technology program will continue to address the development of critical enabling technologies needed to insure growth of a commercial mobile satellite service in the United States. This effort, in cooperation with U.S. industry, Canada, and other government agencies, will help implement a first-generation commercial system at the end of the decade.

The mobile communications technologies activity will accelerate the introduction of a commercial mobile satellite service in the United States and will develop power, bandwidth, and orbital-slot efficient ground segment technology and networking techniques needed to insure its growth.

In fiscal year 1986, development on ground segment technology is continuing. Definition of low cost, high gain rooftop vehicle antennas which can at least double the number of orbital slots available has been completed and development of engineering hardware models is underway. Design is continuing on terminal and networking techniques that will result in voice transmissions approximately six times more efficient in power and bandwidth than the new cellular terrestrial technology and increases information (voice plus data) transmission. NASA will continue to work with the private sector and other government agencies to define a field test planned for late 1986. To achieve this, and to foster cooperation during the experimental phase, seven Memoranda of Understanding have been signed. There represent almost 30 government agencies.

Fiscal year 1987 mobile communications technology activity will focus on field tests of advanced concepts in an operational-like environment. These initial tests, which will involve NASA, other agencies, United States industry, and Canada, are a first step in tying together the advanced technology elements under development for a future mobile satellite communications experiment.

Search and rescue

The Search and Rescue Program is an international cooperative program which demonstrates the use of satellite technology to detect and locate aircraft or vessels in distress. The United States, Canada, France, and the Soviet Union developed the system in which Norway, the United Kingdom, and Sweden also participate.

A four-satellite system is now in service (two United States and two U.S.S.R. satellites) and has been credited with saving over 500 lives in numerous worldwide incidents. The resources requested reflect the fact the primary responsibility for this program has been transferred to NOAA.

Technical consultation and support program

The technical consultation and support program will continue to provide for studies of radio interference, propagation, and special systems required for the growth of existing satellite services and the extension of new satellite applications. Support to the Department of State, the Federal Communications Commission, the National Telecommunications and Information Administration, and other agencies in the development of frequency and orbit sharing techniques and strategies for upcoming World Administrative Radio Conferences (WARC's) will continue.

Experiment coordination and operations support program

The experiment coordination and operations support program assists other Federal agencies and public sector organizations in the development of experimental satellite communications for emergency, disaster and public service applications. Operations of the Applications Technology Satellite-3 are continuing through contracts with the University of Miami.

COMMITTEE COMMENTS

The Committee rejects the administration's exclusion of the program from NASA's fiscal year 1987 budget request and authorizes \$85 million for the ACTS program in fiscal year 1987. Since the original authorization of the ACTS program in the fiscal year 1985 NASA authorization bill, the Committee has supported ACTS because it is critical to the future of the United States in the world communication market. Furthermore, the Committee continues to believe that the development of the ACTS technologies are an appropriate research and development function for our Nation and for NASA, in particular.

The Committee notes that in the fiscal year 1985 NASA authorization Public Law 98-361, section 101), NASA is directed to conduct a flight test of ACTS no later than 1989. The Committee recognizes, however, that due to the *Challenger* accident, the ensuing backlog of payloads and missions, and budgetary constraints, NASA will be unable to launch ACTS as directed by statute. The authorization of \$85 million ACTS will, nevertheless, enable NASA to complete ACTS so that it is launch-ready by mid-1990 and available for launch before the scheduled 1991 launch date of the competing European satellite technology. Accordingly, the Committee expects NASA to complete the ACTS by mid-1990 as an affirmation of the priority the United States places on its continued preeminence in communications satellite technologies.

INFORMATION SYSTEMS—\$21,200,000

The Committee authorizes for fiscal year 1987 administration's request of \$21.2 million.

The objectives of the information systems programs are to develop and demonstrate advanced capabilities for managing, distributing, and processing data and information; implement information systems standards and provide common software to lower data systems costs; and improve access to, and rapid delivery of, space data and advanced data systems in support of the Nation's satellite programs and the space science and applications projects.

This program provides for timely development of data system capabilities to meet the needs of flight missions and major space science and applications programs. The early demonstration of capabilities has a high potential for reducing ground data systems development risks and for providing timely delivery of data to researchers.

COMMERCIAL PROGRAMS—\$40,300,000

The Committee authorizes, as follows, \$40.3 million for Commercial Programs, \$5 million below the administration's budget request.

Summary of funding levels for fiscal year 1987

Technology utilization.....	\$13,300,000
Commercial use of space	27,300,000
Total.....	40,300,000

TECHNOLOGY UTILIZATION—\$13,300,000

The NASA Technology Utilization Program is designed to enhance national economic growth and productivity through the transfer of aerospace technology resulting from NASA's research and development programs to the nonaerospace sectors of the economy. In addition to the aerospace industry, NASA's technological advances have found use in important public sector areas such as medicine, transportation, rehabilitation and public safety. The objectives of the program are to (1) accelerate and facilitate the application and use of aeronautics and space technology by the U.S. private sector; (2) facilitate multiple secondary uses and application of NASA technology by the public and private sectors and academia; (3) continue to improve NASA's technology transfer process; and (4) promote applications of NASA's expertise to nonaerospace needs of the Nation.

COMMERICAL USE OF SPACE—\$27,000,000

The objective of the Commercial Use of Space Program is to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology, space-based research and development. Expansion of the level of private sector investment in commercial space activities will help the United States to retain its leadership in science and technology and will accrue associated benefits to our Nation. This program will be built on Shuttle and related space-based operational capabilities. The program is responsive to the President's National Space Strategy and National Policy on the Commercial Use of Space, both of which direct NASA to expand private sector investment and involvement in space activities.

Fiscal year 1986 activities include the implementation of the National Policy on the Commercial Use of Space, maintenance of an organizational focal point for commercial programs at NASA, and the fostering of commercial use of and access to space. These efforts include the establishment of additional Centers for Commercial Development of Space (CCDS), increased accessibility to NASA facilities and equipment, small focused research efforts on processes having commercial potential, and the incorporation of other functions designed to facilitate private sector utilization of space for commercial ventures.

Fiscal year 1987 activities will provide a continuation and some enhancement of the fiscal year 1986 program. These efforts are designed to encourage significant private investment in commercial enterprises that take advantage of the unique characteristics of space, such as vacuum, microgravity, and radiation.

In fiscal year 1987, the third round of CCDS selections will occur, which will complete the constellation of centers at around fifteen to eighteen. These consortia of industry, academia, and non-NASA government participants are expected to encourage effectively the development of high technology space-related research having direct commercial interest and application. Joint endeavor and other space act agreements are expected to increase substantially as the CCDS move forward in their research activities and as companies further define their research interests and programs. As of

January 1986, NASA had executed 65 space act agreements with U.S. companies, of which 52 were research-related (joint endeavor agreements, technical endeavor agreements and industry guest investigators), nine were commercial hardware-related, and two represented divestitures of government programs (expendable launch vehicles).

COMMITTEE COMMENTS

The Committee's reduction of \$5 million from the administration's request for commercial use of space is a general reduction which may be applied at NASA's discretion.

The Committee notes the selection of four more Centers for the commercial development of space and continues to support this space commercialization initiative as a highly leveraged investment which could yield some of this Nation's earliest and most productive commercial space endeavors. For this reason, the Committee expects that NASA will not apply any of the \$5 million reduction to its support for the centers for the commercial development of space.

AERONAUTICAL RESEARCH AND TECHNOLOGY—\$371,000,000

The Committee authorizes for Aeronautical Research and Technology \$371 million for fiscal year 1987, compared to the administration's budget request of \$376 million. The \$5 million reduction is a general reduction which the Committee expects NASA to allocate at its discretion.

The objective of the Aeronautical Research and Technology Program is to contribute materially to the enduring preeminence of U.S. civil and military aviation by (1) conducting appropriate levels of disciplinary and systems research at the leading edge of technology in those areas critical to the continued superiority of U.S. aircraft; (2) maintaining the research centers in positions of excellence in facilities and technical staff; (3) assuring timely transfer of research results to the U.S. aeronautical industry; (4) assuring appropriate involvement of universities and industry; and (5) providing aeronautical development support to other government agencies and U.S. industry.

Conducted well in advance of and independent of specific applications, the aeronautical research and technology program includes both fundamental research in the aeronautical disciplines and systems research directed at interaction among disciplines, components, and subsystems applicable to general classes of advanced aircraft. The program involves participation by aeronautical manufacturers from the industrial base essential to both military and civil aviation to ensure that the technology is compatible with practical design considerations and can be successfully transferred into application.

The Systems Technology Programs are designed to extend the scientific discoveries and findings flowing from the Research and Technology Base through applied research to demonstration and validation for selective technologies, which thereafter provide the design phase for advanced military and commercial products undertaken by private industry.

Rotorcraft systems technology

The rotorcraft systems technology program conducts research on two fronts. The first involves comprehensive noise prediction and full-scale wind tunnel tests. The second involves the X-wing rotor demonstration test on the rotor systems research aircraft (RSRA).

In full-scale testing, an Army LHX main rotor was tested in the newly upgraded 40 X 80-foot wind tunnel. The first full-scale test of main rotor/tail rotor aerodynamic interference was also run in the 40 X 80-foot wind tunnel. Acquisition of a pressure-tapped main rotor and a hingeless rotor will be started for a fiscal year 1987 tunnel entry to investigate high-speed airloads and rotor-dynamic stability.

Under the joint DARPA/NASA RSRA/X-wing Program, the prime objective is to perform an X-wing rotor conversion from rotary to stopped-rotor flight and return to rotary wing flight. The flight research program will also investigate the dynamic stability, performance, and rotor control characteristics of the X-wing rotor system.

In 1986 the fabrication and assembly of the X-wing rotor system will be completed, and the rotor system will be installed on the propulsion system testbed (PSTB) and subsequently on the aircraft. Preceding flight, the X-wing rotor system will be extensively tested on the PSTB, an "iron bird" ground-based facility, and the reliability of the flight control system will be extensively tested in the vehicle management system laboratory which was specifically developed to test the unique X-wing flight control system.

In fiscal year 1987 the X-wing flight test program is planned to be completed. The program will also be generating ground-based piloted simulation PSTB data and vehicle management systems data in support of the flight investigation of the X-wing rotor on the RSRA. This fast-paced, advanced technology program will require extensive, coordinated testing in 1987 which is crucial to the success of the flight investigation and will require special NASA capabilities to support the contractor's efforts. In particular, the flight testing will culminate in the historic demonstration of conversion from rotary to stopped-rotor flight for cruise and a reconversion to rotary flight for landing.

High performance aircraft systems technology

The objective of a high-performance aircraft systems technology program is to generate validated engineering methods and design data to develop advanced high-performance, high-speed aircraft for military and civil applications. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel experimental research, flight research tests of aircraft.

In the joint NASA/Air Force Advanced Fighter Technology Integration (AFTI) Program, the AFTI/F-16 automated maneuvering attack system flight phase is being completed. The AFTI/F-111 mission adaptive wing project will complete the flight research activity to validate predicted performance improvements, including a range increase of 25 percent, resulting from its variable camber airfoil. In the F-15 highly integrated digital electronic control (HIDEC) program, which builds on the digital electronic engine

control and F-100 engine model derivative programs, flight research testing has begun to validate 10- to 15-percent aircraft performance improvements through integrated digital electronic controls.

In the NASA/DARPA X-29A forward-swept wing flight demonstration program, the aircraft will complete the baseline flight program in 1986 to validate predictive tools and exploit the advanced technologies designed into the experimental aircraft. The F-18 high angle-of-attack flight testing will begin in the third quarter of fiscal year 1986 on an unmodified F-18. The goal of the program is a flight-validated data base for design of highly maneuverable aircraft with a 90-degree angle-of-attack capability.

During fiscal year 1986 the turbine engine hot section technology (HOST) program continues to address the issues involved in engine durability. The objectives are to establish predictive methods for the structural response and life of hot section components by developing analysis methods, instrumentation and verification test methodology. During this year the new high-temperature structures and fatigue laboratory at Lewis Research Center began operation.

As part of the activity to develop higher performance longer life turbine blade materials, the ceramic research program has continued to make progress in fiscal year 1986. For example, initial studies on the application of ceramic composites for turbine blades have shown promise for the development of "tough" ceramics.

The objective of the joint NASA/Navy oblique wing program is to establish a flight-validated data base to apply the technology to future civil and military aircraft. For over forty years, NASA has investigated oblique wing technology, including wind tunnel tests, simulations, aircraft design studies, and low-speed manned and unmanned flight tests. These studies have indicated significant performance advantages for an oblique wing aircraft, as compared to a conventional swept wing, for missions requiring both efficient subsonic cruise and supersonic dash performance. In addition, the concept offers significant improvement in aircraft carrier airplane spotting ratios for Navy flight deck operations.

The oblique wing technology development will be completed by the design, construction, and flight evaluation of an aeroelastically tailored composite oblique wing at transonic and supersonic speeds. The NASA F-8 digital fly-by-wire (DFBW) test aircraft will be utilized as the research testbed for the flight program. A wing preliminary design contract has been awarded and will provide the basis for the final design and initiation of the fabrication of the wing, pivot mechanism, and required modifications to the F-8 DFBW testbed. This activity will lead to the start of the flight test program in 1989.

The flight research activity in fiscal year 1987 will involve a variety of high-performance aircraft to investigate advanced concepts. The F-15 HIDECA will complete flight test validation of performance improvements resulting from propulsion system variable operating line control. The NASA/DARPA X-29A aircraft program will be expanded to include Air Force participation in a follow-on flight research program on the first aircraft within the established envelope (angle of attack less than 20 degrees). The second X-29A aircraft will be modified to include a spin chute to enable flight re-

search testing of the forward-swept wing technologies above 20 degrees angle of attack.

In 1987 the contract for final design, fabrication, and ground qualification testing of the oblique wing and F-8 DFBW aircraft system interfaces and modifications will be awarded. In-house NASA/Navy wing aerodynamic design and direct project support research and technology activities will be continued.

Advanced propulsion systems technology

The objective of the advanced propulsion systems technology program is to develop advanced concepts for future aircraft propulsion systems in high-payoff technology areas through the focusing of fundamental research and technology and integration of advanced propulsion components.

Activities in the advanced turboprop systems program are devoted to establishing concept feasibility and providing the broad research and technology data base necessary for achieving the concept's full potential. Information on aerodynamic performance, aeroelastic stability, and acoustic environment will be obtained for the data base and used partially to support flight test programs for verification and for obtaining data under actual flight conditions. The 9-foot-diameter large-scale advanced propeller (LAP), to be used during flight tests, and the 2-foot-diameter aeroelastic model of the LAP have been fabricated. Wind tunnel tests of the aeroelastic model confirmed stability up to a Mach number of 0.85, the highest planned during flight testing. The LAP was static ground-tested at the Wright-Patterson Air Force Base for takeoff performance, blade stress levels, and stall flutter, and all were found to be as predicted.

During fiscal year 1986 the LAP will be tested in a high-speed wind tunnel for performance and flutter boundaries. One-ninth scale model tests of the propeller test assessment flight test aircraft with the turboprop installed have provided flutter and high-speed drag characteristics. In 1986 the aircraft model will be used to determine low-speed stability and control characteristics, and a ground test will be performed on the LAP mated with the flight gearbox and turboprop power section.

Ground tests of the General Electric unducted fan engine, a gearless counterrotation propfan concept, were initiated in September 1985 and were completed in July 1986.

In the general aviation/commuter engine technology program, aimed at raising the performance level of small turbine engines to match that of large engines more proportionately, work is focused on providing fundamental measurements to lead to a detailed understanding of how improvements can be made.

In fiscal year 1987 advanced turboprop systems research will emphasize the flight test of the LAP in a propeller test assembly for concept verification and broadening of the data base for cabin acoustics and turboprop/airframe installation aerodynamics. The LAP, nacelle, and turboprop power section will be installed on a modified Gulfstream II aircraft for flight testing in fiscal year 1987. The flight tests will evaluate large-scale structures, aeroelastics, propeller source noise, and untreated cabin environment at a variety of flight conditions up to a Mach number of 0.85 and an altitude

of 35,000 feet. More fundamentally, cabin acoustics research is being performed and will include development of analytical techniques to predict cabin environment for various inputs of propeller source noise and cabin treatments that have the potential to achieve attenuation levels required for high-speed propellers.

Numerical aerodynamic simulation

The numerical aerodynamic simulation (NAS) program objective is to augment the Nation's capabilities in computational fluid dynamics and other areas of computational physics by developing a preeminent capability for numerical simulation of aerodynamic flows. The heart of this system is the high-speed processors, which will be upgraded when new supercomputers, at least four to six times more powerful than existing machines, become available. These machines will provide the large-capacity and high-speed computational capability required in advanced fluid dynamic research and applications.

NASA began the study and planning phase of the NAS program in the research and technology base in fiscal year 1983 and began system development in fiscal year 1984. The system design review was held in 1984 and formalized the design of the NAS system. The system software development contractor began development of the network language and protocols during fiscal year 1984.

NASA began major hardware procurements for the NAS in fiscal year 1984, leading toward assembly of the initial operating configuration during fiscal year 1985. Full-scale development of the NAS network hardware began with the delivery of the integrated support processor complex (front-end computers and supporting equipment) in mid-fiscal year 1985. The first high-speed processor, a Cray 2 supercomputer, was delivered late in fiscal year 1985 and integrated into the NAS network.

The first part of the fiscal year 1986 is an intense test and integration period leading to operational status of the NAS initial operating configuration (IOC) during the third quarter of fiscal year 1986. During fiscal year 1986, NASA will complete construction for the NAS facility.

Fiscal year 1987 will be the key year in the development of the NAS system. The NAS building will be occupied and the second high-speed processor (HSP-2), which will be four to six times more powerful than HSP-1, will be installed. Secure (classified) processing will be initiated with the move into the new building. During fiscal year 1987 the IOC, built around HSP-1, will be used to obtain the first solution for subsonic and transonic viscous flow about complete aircraft configurations. It will also be used to provide, among other things, pathfinding viscous flow solutions to supersonic/hypersonic airframe/propulsion integration for advanced configurations being studied in the national aerospace plan program. The acquisition and installation of the HSP-2, which constitutes the NAS extended operating configuration (EOC), will complete the initial planned architecture of the NAS system. It will serve as the foundation for the upgrading of the major subsystems in the building toward the EOC. During this period, system software development will continue, and all new components will undergo extensive test integration.

COMMITTEE COMMENTS

The Committee's general reduction of \$5 million from the administration's fiscal year 1987 request in no way indicates any lessening of support for NASA's aeronautical research and technology programs. Consistent with its support in previous years, the Committee recognizes the significance of these programs to our Nation's position in the global arena of aeronautical technology and sales. The \$5 million reduction is to be allocated to NASA's discretion.

The Committee authorizes the administration's full request of \$26 million for the Advanced Turboprop Propulsions Systems Program. For the past two years, the Committee has supported a full-scale flight test of the Advanced Turboprop program technologies by 1987. The Committee recognizes that NASA and the prime contractor are prepared to conduct this flight test by early 1987 and, therefore, expects the flight test to be conducted during this time-frame to ensure a timely delivery of the test results to industry.

The Committee's general reduction of \$5 million is not to be applied to any aeronautical program that the Committee has specifically authorized in this fiscal year 1987 authorization.

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY—\$40,000,000

The Committee authorizes \$40 million for Transatmospheric Research and Technology, which is NASA's contribution to the National Aerospace Plane Program. This authorization is \$5 million below the administration's budget request of \$45 million.

NASA, in conjunction with DOD, is developing the technology base for a potential national aerospace plane. The objective of the NASA transatmospheric research and technology program is to accelerate the development of the critical enabling technologies for a potentially revolutionary new class of hypersonic/transatmospheric vehicle. Such a vehicle could be capable of horizontally taking off from and landing on conventional runways, using airbreathing propulsion up to, or near, orbital speed, and providing rapid and low-cost access to space. This augmentation of previous NASA in-house research and technology base efforts would accelerate the development and validation of key technologies through fabrication of components and subsystems and by testing in ground-based facilities and small-scale flight experiments. The critical technologies include efficient airbreathing propulsion, with emphasis on scramjet techniques which provide net thrust from takeoff to near orbital speeds; reusable thermal structures that can withstand repeated combinations of extreme peak heating and long-duration heat loads; and complete integration of the propulsion system with the airframe for minimum weight with good performance throughout a broad range of acceleration, cruise, and maneuvering. They are a necessary precursor to future decisions on a demonstrator research aircraft program. These validated technologies could provide the data required to design and integrate complex propulsion and structural systems into a vehicle configuration capable of transatmospheric flight.

This program is an outgrowth of NASA's ongoing aeronautics and space research and technology programs. It is a multicenter

program (Ames, Langley, and Lewis) generating the technologies required to provide the options afforded by airbreathing transatmospheric vehicles. The opportunities for exploiting this regime to advance national interests are broadly recognized—including launch vehicles, hypersonic transports, and military applications.

NASA's supporting activities in the research and technology base include research in airbreathing hydrogen-fueled scramjet propulsion technology, advanced high-temperature materials and thermal structural concepts, and computational fluid dynamics—the three critical technologies for transatmospheric vehicle applications. The fiscal year 1987 program will focus on development of analysis and prediction techniques and validation of the performance for airbreathing propulsion concepts, actively cooled high-temperature structures, cryogenic insulated tankage, configuration aerodynamics, and propulsion system/aircraft integration characteristics.

COMMITTEE COMMENTS

In 1985, the administration's Aeronautical Policy Review Committee announced three specific national aeronautical research and development goals, one of which was to develop the technologies which would enable the development of hypersonic and transatmospheric vehicles. In accordance with this goal, the fiscal year 1987 budget request for NASA and DOD provides for a new start of the National Aerospace Plane (NASP) Program. The budget request for NASA's contribution to this program, Transatmospheric Research and Technology, is \$45 million, and the Committee authorizes \$40 million.

The Committee believes that the NASP represents an important opportunity for revolutionary advances in U.S. aeronautical and space capabilities. Regrettably, this program, if successful, will not be operational soon enough to assist in the space recovery plan during the 1990's. Nevertheless, if the NASP is successful, it should create a dramatically new dimension in our national aerospace capabilities.

Based on testimony during the fiscal year 1987 NASA authorization hearings, the Committee understands that national security missions may be the earliest applications for the product of the NASP program. Nevertheless, the Committee believes that the program's potential for reducing the cost of delivering payloads to orbit and for rapid servicing of the space station and other civilian space-based facilities make the NASP an equally attractive national asset to our civilian space program. While the application of the NASP program for commercial air transport may be a more distant use, it, nevertheless, is another potential application which the Committee believes must be considered in the development of this new technology.

The Committee recognizes that the major technological barriers to the successful completion of the NASP program—airbreathing propulsion, structures and materials, and aerodynamic computational methods—are the most demanding technological issues confronting our national aeronautical capabilities. Yet, as challenging as they are, their resolution is consistent with the traditional pioneering challenges which NASA has undertaken in the past and

should continue to undertake. NASA's role in the NASP program is appropriate and necessary.

Furthermore, the Committee notes that other nations—the Soviet Union, Japan, and the ESA—are also in various stages of examining and testing similar technologies. If the United States expects to maintain its leadership in aerospace development, the NASP program should be aggressively pursued.

For these reasons, the Committee endorses the NASP program and NASA's role in this program. The Committee's authorization of \$40 million reflects a general reduction of \$5 million from the budget request, which NASA may apply within Transatmospheric Research and Technology at its discretion.

SPACE RESEARCH AND TECHNOLOGY—\$200,200,000

The Committee authorizes \$200.2 million for Space Research and Technology, \$20 million above the administration's request of \$180.2 million.

The overall goal of the space research and technology program is to advance the technology base in support of NASA's role as an effective, productive, and long-term contributor to the continued preeminence of the United States in space. The specific objectives of this program are to: (1) support a broad-based advanced technology program designed to provide new concepts, materials, components, devices, software and subsystems for use in U.S. civil and military space activities; (2) assure preeminent national capability through extensive participation in the program by the NASA centers, other government agencies, universities, and industrial research and technology organizations; and (3) support a strong institutional base to maintain NASA centers in positions of recognized excellence in critical space technologies.

The fiscal year 1987 program supports these objectives by placing emphasis on disciplinary technologies which provide the data and understanding to create new opportunities for future national civil, military, and commercial space missions. It also emphasizes systems technology programs to obtain fundamental data from in-space experimentation and to transfer advanced technology into space programs through proof of concept to support technology readiness for anticipated applications.

COMMITTEE COMMENTS

The Committee has authorized an additional \$20 million for Space Research and Technology for a total authorization of \$200.2 million. This additional authorization is earmarked for advanced technology development toward next-generation launch systems that would provide low-cost, reliable access to low-earth and geosynchronous orbits.

The *Challenger* accident is forcing our Nation to reexamine our present and future space launch capabilities. Reliance on a single launch system is no longer an acceptable space policy. If the United States expects to develop future space launch systems that are more cost-effective and diversified than those presently in place, a more serious commitment to the fundamental research and technology that will support these systems must be made.

The Committee recognizes that there are many options to consider for our Nation's next-generation launch systems. Furthermore, there are a vast number of technologies, as identified by the NASA/DOD Space Transportation Architecture Study, which will require resolution during the next several years if we intend to stay on the forefront in space launch systems. NASA's Space Research and Technology (R&T) programs are the appropriate focal point for the resolution of the technologies that are critical to our future space launch capabilities. This is confirmed by the National Commission on Space, which recommended tripling NASA's Space R&T budget over the next few years. The Commission recommended this growth in the Space R&T budget to accelerate the necessary work in many critical fields, including space propulsion, aerobraking, and automation and robotics for autonomous pre-launch and launch systems.

Although an additional authorization of \$20 million does not represent a rate of growth that will accommodate all of the work that the Commission has recommended, the Committee believes that the additional authorization should enable NASA to pursue more aggressively those technologies which will be the key to our Nation's future space launch capabilities.

TRACKING AND DATA ADVANCED SYSTEMS—\$17,100,000

The Committee authorizes \$17.1 million for Tracking and Data Advanced Systems, a funding level which is identical to the administration's request.

The overall objective of the Advanced Systems Program is to study and develop tracking and data systems and techniques required to: (1) obtain new and improved tracking and data capabilities which will meet the needs of new missions; and (2) improve the cost effectiveness and reliability needed for overall support of the total mix of spaceflight missions.

As a small but vital element of the Space Tracking and Data Systems Program, this activity continues to focus on assessing and making use of the dramatic changes taking place in telecommunications, electronic microcircuitry and computer technology. Such effort is critical for proper planning and for the application of cost effective and reliable new technology to future support capabilities. Ongoing work includes investigations of upcoming missions and studies of ground systems and telecommunications links to determine design approaches and to assess overall tradeoffs for the lowest life-cycle costs to support future space missions.

Activities planned for fiscal year 1987 include efforts aimed at obtaining location accuracies to the one-meter level for Earth orbiting spacecraft, which would make possible a new class of high-precision Earth observatory missions on the Shuttle, space station, and free-flying spacecraft. The techniques to be studied include a specialized use of DOD's Global Positioning System and Very Long Baseline Interferometry.

SPACE FLIGHT, CONTROL, AND DATA COMMUNICATIONS—
\$3,096,000,000

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY—\$884,400,000

The Committee authorizes \$884.4 million for fiscal year 1987, \$139 million more than the administration's request.

With the January 28, 1986 accident of the Space Shuttle *Challenger*, the number of space shuttles available for flight was reduced from four to three—*Columbia* (OV-102), *Atlantis* (OV-104), and *Discovery* (OV-103). Before this accident, the Space Transportation System had conducted 24 successful space shuttle missions. All shuttle flights have been postponed until the shuttle's Solid Rocket Motor (SRM) has been satisfactorily redesigned and requalified and until other shuttle-related technical and safety concerns raised since the *Challenger* accident have been adequately resolved. The downtime for the shuttle fleet is scheduled for at least 2 years from the date of the accident, which would put the next shuttle flight in early 1988.

Shuttle Production and Operational Capability Development provides for the national fleet of space shuttle orbiters, including main engines, and provides for the launch site facilities, initial spares, production tooling, and related supporting activities to meet the needs of NASA, DOD, and other domestic and international users of space. More specifically, the line item contains the orbiter production for flight hardware improvements and mission kits; the procurement of spares inventory for the operational orbiter fleet, including major structural orbiter components; the residual development tasks for the orbiter, main engine (SSME), external tank (ET) and solid rocket booster (SRB); Johnson Space Center (JSC) mission operations capability development; the equipment provisioning of the facilities of launch and landing at the Kennedy Space Center (KSC); the development of the filament wound case (FWC) solid rocket booster; the initial lay-in of spares and ground support equipment; and the rate tooling for the ET and SRB.

Orbiter

The Presidential Commission that investigated the *Challenger* accident concluded that the cause of the accident was a failure of the right Solid Rocket Motor (SRM) aft field joint, which allowed combustible hot gases to burn through the Solid Rocket Booster (SRB) case membrane. The gases that escaped the SRB then weakened or penetrated the external tank and caused the vehicle structural breakup and loss of the *Challenger* and crew.

The Commission also concluded that the design of the joint was flawed and that the following factors, either alone or in some combination, contributed to the joint failure:

1. Extremely cold ambient temperatures and possible ice in the joint;
2. Joint putty performance;
3. Out-of-round conditions between the two segments joined at the right SRM aft field joint;
4. The dynamic or rotational characteristics of the case segments during launch.

In response to the findings of the investigation, NASA established a SRM Redesign Team to select and flight-quality a new SRM design which takes advantage of existing hardware; a panel of the National Research Council is overseeing this effort. NASA intends to conduct four hot-fire qualification tests of the new SRM design before it is approved for flight. In addition, NASA has initiated four contracts to design a new SRM that does not take advantage of existing hardware. These designs will be available for further evaluation if the SRM designs that use existing hardware do not prove satisfactory.

At KSC, the second line of vehicle processing stations is being phased in to support the parallel processing of orbiters for launch. The third Mobile Launch Platform (MLP) is planned to be ready for operations by a September 1986 operational readiness date.

Launch and mission support

Launch and Mission Support provides for the second set of processing stations at KSC to support parallel orbiter processing; the additional astronaut training, mission preparation, and mission operation capabilities; and analyses of program-level improvements for the operations and management of the STS.

The first line of facilities at KSC activated during design, development, test and evaluation (DDT&E) supports the launch processing and checkout of an orbiter vehicle from landing through launch. A second line of processing stations is being phased in to support parallel launch processing of more than one orbiter through the various work areas. The second high bay of the Orbital Processing Facility (OPF) and the second mobile launch platform were activated in late fiscal year 1982 to support parallel processing of two orbiters. The second set of high bays in the Vehicle Assembly Building, the software production facility, and the second control room were activated in fiscal year 1983 to enable parallel processing through mating of the orbiter and the external tank. A solid rocket booster processing and storage facility was activated in fiscal year 1984 to facilitate SRB handling, including off-loading of segments from rail cars, segment rotation, storage for two flight sets (16 segments) and the assembly of SRB aft segments. As a result of the second launch pad's recent activation, parallel processing is possible from the start of OPF flow through launch. A third MLP will be activated in September 1986.

Propulsion systems

The main engines continued their record of excellent flight performance during the eight 1985 flights of the Shuttle. Engine performance was nominal during all flights except for a premature engine shutdown on STS-51F resulting from instrumentation failure. The total SSME ground test experience now exceeds 1,264 tests, totaling approximately 258,000 seconds of test time. This experience includes 240 tests, exceeding 51,000 seconds of operations, at the full power level (FPL).

Development and life certification of the SSME is continuing in support of the flight and ground test program. Design modifications on the high pressure pumps and the hot gas manifold are a continuation of work begun in fiscal year 1983. The purpose of these

modifications is to reduce the SSME operating costs, increase the SSME operating margins, and determine the hardware life and replacement requirement through a certification extension test program.

The operating cost reduction activities are concentrated on the high pressure oxygen and hydrogen pumps. In August 1986, NASA announced the selection of United Technologies as the contractor responsible for the design, development, test, flight certification, and production verification of alternate high pressure and oxidizer turbopumps. These turbopumps are intended to be interchangeable with the current SSME turbopumps, to provide extended life capability, and to enhance safety margins.

The space shuttle main engines were exonerated from contributing to the *Challenger* accident.

The SRB program includes the development of a filament wound motor case. If the FWC effort is successful, it will replace the heavier steel motor case segments for high performance launches. This FWC program will be reconsidered in light of the redesign of the SRW and in light of the delay in the activation and use of the Vandenberg Air Force Base shuttle launch facilities until approximately 1992.

The SRM FWC second development motor (DM-7) was successfully tested in April 1985 in a static test firing. The qualification motor has been processed and is being prepared for static test. The structural test article (STA-2A) successfully passed all but the final load test cycles. The test article failed at 118.5 percent of the engine ignition limit loads. Any decision to replace the test articles will depend on the final redesign of the SRM and upon consideration of the future use of shuttle facilities at Vandenberg Air Force Base.

Performance of the External Tank (ET) on all shuttle flights has been excellent. The ET was also exonerated as a contributing factor to the *Challenger* accident. Emphasis continues on reducing cost and increasing production as the flight rate increases. NASA is implementing improvements in tank manufacturing and processing which will reduce costs.

Changes and systems upgrading

Changes and systems upgrading provides funding for potential changes and system modifications as well as unanticipated new requirements not covered in the budget estimates for the above activities and other program elements.

COMMITTEE COMMENTS

Restoring the Space Transportation System to flight readiness is a task whose budgetary requirements are not completely defined at this time. The reason for this uncertainty is that some issues related to crew escape and egress, launch abort capabilities, test configuration of the redesigned solid rocket booster, and second sourcing of the SRB, to name a few, have not been resolved.

The Committee notes, however, that NASA is prepared to address in fiscal year 1987 a number of the items related to anomaly resolution and correction that were identified in the Fiscal Year

1986 Urgent Supplemental Appropriations Act. Foremost among these is the redesign of the SRB and the correction of components and systems on the critical items list that require attention. The Committee authorizes NASA to address in fiscal year 1987 \$365 million worth of items identified in the Fiscal Year 1986 Urgent Supplemental Appropriations Act.

Also, the Committee has authorized an additional \$200 million in Space Shuttle Production and Operational Capability for implementation of recommendations of the Rogers Commission. The Committee recognizes that an authorization of \$200 million for implementation in fiscal year 1987 of these recommendations may be a conservative estimate. Yet, the Committee does not want this authorization to prejudice any NASA decisions related to the implementation of these recommendations. If additional resources are needed to implement the necessary changes in fiscal year 1987, the Committee expects NASA to consider the availability of funds from other sources.

To perform its oversight responsibilities more effectively, the Committee requests NASA to prepare by, February 1, 1987, a report which details all actions and their associated costs under consideration to implement the Rogers Commission recommendations and to correct and/or resolve the anomalies identified in the Fiscal Year 1986 Urgent Supplemental Appropriations Act. Furthermore, this report should identify which of these actions NASA does not intend to implement and the reasons why.

The Committee notes that NASA intends to apply in fiscal year 1987 approximately \$426 million in funds made available from the Fiscal Year 1986 Urgent Supplemental Appropriations Act. The application of this \$426 million to the additional requirements of \$565 million, as discussed above, results in a shortfall of resources of \$139 million. To compensate for this shortfall, the Committee authorizes \$884.4 million for Space Shuttle Production and Operational Capability, which is \$139 million above the administration's budget request.

The Committee notes with approval the establishment of the Office of Safety, Reliability, and Quality Assurance, which the Rogers Commission recommended, and expects that this Office will elevate within NASA and its contractors the issues of safety, reliability, and quality assurance. The Committee also is supportive of the new Associate Administrator's efforts to enhance the capability and size of the safety, reliability, and quality assurance staffs of headquarters and the NASA centers. Furthermore, the Committee notes with approval NASA's request of the National Research Council for separate audit panels to oversee the redesign of the solid rocket booster and the review of all criticality 1, 1R, 2, and 2R items and hazard analyses. The Committee expects to be kept informed on a regular basis on the progress and results of these two activities.

SPACE TRANSPORTATION OPERATIONS—\$1,350,700,000

The Committee authorizes \$1,350.7 million for fiscal year 1987, \$174 million below the administration request.

Space Transportation Operations provides the standard operational support services for the primary U.S. space launch system: the space shuttle. Within shuttle operations, flight hardware is produced, refurbished and repaired; and manpower, propellants, and other materials are furnished to conduct and support both flight and ground operations. The space shuttle operations program provides for the launch of NASA missions and, on a reimbursable basis, DOD, other U.S. Government, commercial, and international missions. The launch policy of foreign and commercial payloads is under reconsideration by the administration. The current target date for the resumption of shuttle flights is early 1988.

The space shuttle provides launch services to non-NASA users on a reimbursable basis, as determined by the greater of each payload's length or weight. Launches occurring during the period fiscal year 1986 through fiscal year 1988 have been priced at \$71.0 million (1982 dollars) for commercial launches and \$55.5 million (1982 dollars) for DOD launches. The shuttle pricing policy for non-NASA commercial customers for fiscal year 1989 is a minimum bid of \$74 million (1982 dollars), while the DOD price for shuttle flights is \$60 million (1982 dollars) for flights during the period fiscal year 1989 through fiscal year 1991. These most recent shuttle pricing policies for commercial and DOD shuttle customers may be reconsidered in light of changing Shuttle launch policies.

The shuttle operations budget request funds three principal areas: flight operations, flight hardware, and launch and landing operations. Flight operations consists of mission support, integration, and operational support. The flight hardware program provides for the procurement of the external tanks, solid rocket motors, booster hardware, and propellants; spare components for the SSME's; orbiter spares; ET disconnect and SRB rate gyros sustaining engineering and logistics support for external tank/solid rocket booster/main engine flight hardware elements; and maintenance and operation of flight crew equipment. Launch and landing operations provides for the launch and landing operations of the Space Shuttle and its cargo.

Following the *Challenger* accident, significant reductions have been made in activities in Space Transportation Operations. The actions taken involve lay-offs as well as cuts in procurement of materials and other deferrals. For example, in the ET area about 1,300 people have been laid-off. In the Solid Rocket Booster area, staffing levels have been reduced by about 950 equivalent people by a combination of lay-offs and a 4-day work week. Launch Operations Contractors have been reduced by about 1,450 people and Flight Operations Contractors by about 300 people.

The current status and planning for the major operations and flight hardware projects are:

Flight operations

The flight operations activity is predominantly maintenance and operations of flight support and crew training facilities, sustaining engineering for the integrated shuttle systems including the orbiter and flight software, and crew training and mission support activities. The demand for sustaining engineering activities has increased as the result of the accident while there have been reduc-

tions in flight-related output of crew training and mission support facilities. These reductions in the flight specific activities have been partially offset by devoting resources to required systems upgrades consistent with the recommendations of the Rogers Commission. For example, the Shuttle Mission Simulators have been reduced from the 7-day 3-shift operations and 140 hours of training per week to 80 hours of training necessary for the retention of astronaut proficiency. This savings in operating time has been largely offset with efforts to improve the fidelity of the simulators and to work off a large backlog of changes that existed prior to the accident. These modifications will continue as changes are made to the flight hardware and launch process during the flight hiatus to insure the simulators accurately mirror the flight environment.

External tank

The external tank project had planned to deliver 15 flight sets of hardware during fiscal year 1987. Currently, about 1,300 personnel have been laid off. Several support contracts and previously subcontracted assemblies have been taken over by the prime contractor to use existing skilled manpower. The production schedule has been dropped to eight in fiscal year 1987 and an evaluation is being made of further reducing the deliveries.

Solid rocket booster

The solid rocket booster projects had planned to deliver 17 flight sets of hardware during fiscal year 1987. As a result of the joint redesign activity, the solid rocket motor deliveries will be reduced to one or two per year and the booster hardware deliveries will be limited to three during fiscal year 1987. The combined December 1985 manpower levels for United Space Boosters, inc. and Morton Thiokol have been reduced by one-third.

Launch and landing operations

Prior to the STS 51-L accident, launch operations had been conducted on a full three-shift schedule with substantial overtime. The shuttle contractors are now operating on two-shift while the cargo contractors have been reduced to one shift. The cargo contractors will be maintained at approximately the current levels until a previously planned consolidation and recompetition are completed early in 1987. The initial termination of 450 personnel in operations and the attendant support areas has been increased by 1,000 as a result of the extended flight delay. These contractors are currently working on 377 open changes for the three Orbiters which include modifications, inspections, instrumentation, payload wiring accommodations, and Centaur deconfigurations. Additional modifications and support operations are anticipated as a result of the design reviews and process evaluations now being conducted on all elements of the Shuttle configuration. Other activities include maintenance of the extensive shuttle facilities and completion of many open changes for the facility processing equipment. To preserve critical skills, some work that previously would have been subcontracted will now be performed by the prime contractors.

Expendable launch vehicles

On May 3, Delta rocket 178 exploded when its main engine and vernier engines shut down prematurely. Shutdown of the engines was caused by an electrical short, which caused the engine propellant valves to close, cutting off fuel and oxidizer to the main engine and vernier engines. The lack of control from the engines led to the breakup of the vehicle in the atmosphere and the loss of a GOES weather satellite.

The electrical problem has been identified and corrected, and the September 5, 1986, Delta launch was a complete success. Also, NASA has made available to the Indonesian Government Delta rocket 181 for the launch of the Indonesian satellite Palapa B-3, in early 1987.

COMMITTEE COMMENTS

The Committee's authorization for Space Transportation Operations, \$1,350.7 million, a funding level that is \$174 million below the administration's budget request, is based on savings in shuttle operational costs in fiscal year 1987 and the loss or return of shuttle services payments from commercial customers.

NASA projects that its budget requirements for shuttle operational costs in fiscal year 1987 will be \$526 million less than anticipated in the budget request. This reduction in budget requirements is partially offset by the loss or return of \$352 in reimbursables from shuttle commercial customers. This results in a net reduction of \$174 million in fiscal year 1987 budget requirements and a corresponding reduction from the requirements and a corresponding reduction from the administration's request for the Committee's authorization.

The Committee notes the actions that were taken by the Senate and House Armed Services Committees to reduce by up to \$556.3 million DOD's shuttle services payments to NASA for fiscal year 1987. The Senate, however, approved the Danforth amendment to the fiscal year 1987 National Defense Authorization Act to restore \$556.3 million to the fiscal year 1987 DOD authorization bill for these Shuttle service payments. The loss of these reimbursements would have a severe adverse effect on the civilian space program. The Committee, therefore, assumes that NASA will have available in fiscal year 1987 the DOD shuttle services as previously anticipated. However, the Committee will closely monitor the activities of the appropriate Appropriations subcommittees to make sure these monies are made available in fiscal year 1987.

SPACE AND GROUND NETWORK, COMMUNICATIONS, AND DATA
SYSTEMS—\$860,900,000

The Committee authorizes \$860.9 million for Space and Ground Network, Communications, and Data Systems, a funding level that is \$62 million above the administration's request.

The purpose of this program is to provide vital tracking, command, telemetry, and data acquisition, communications, and data processing support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided on

a reimbursable basis for projects of DOD, other Government agencies, commercial firms, and other countries and international organizations engaged in space research.

Support is provided for sounding rockets and balloons, research aircraft, Earth orbital, and planetary and solar system exploration missions. Included in Earth orbital support are the space shuttle and spacelab flights missions. The various types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific and space applications data from onboard experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) transmission of commands from ground stations to spacecraft; (e) communication with astronauts; (f) transfer of information among the various ground facilities and control centers; (g) processing of data acquired from the launch vehicles and spacecraft; and (h) reception of television transmission from space vehicles. Such support is essential for achieving the scientific objectives of all flight missions, for executing the decisions which must be made to assure the success of these flight missions, and, in the case of shuttle missions, to insure safety of the crew.

Tracking and acquisition of data for the spaceflight projects is accomplished through the use of a worldwide network of NASA ground stations, and by the first of a system of three tracking and data relay satellites in geosynchronous orbit working with a single highly specialized ground station. Ground facilities are interconnected by terrestrial and communications satellite circuits which are leased from communications carriers, both domestic and foreign. This interconnection provides the communications capability needed between spacecraft and the control centers from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established three basic support capabilities to meet the needs of all classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports Earth orbital missions; the Deep Space Network (DSN), which supports planetary and interplanetary flight missions; and the Tracking and Data Relay Satellite System (TDRSS), which will provide all low Earth-orbital mission support when it becomes fully operational. The STDN will continue to provide Earth orbital support until three TDRSS spacecraft are launched, properly positioned, and have completed pre-operational testing to ensure reliable mission operations support.

When the TDRSS is fully operational, six selected STDN ground stations will be phased out. Two STDN stations (Merritt Island and Bermuda) will be retained to provide prelaunch, launch, and shuttle landing support.

The space network consists of the TDRSS and a number of NASA ground elements to provide the necessary tracking, telemetry, command, and communication services to low Earth-orbital spacecraft. The TDRSS itself will consist of a three-satellite system in geosynchronous orbit and a single ground terminal located at White Sands, NM. The satellites communicate with the user spacecraft in space and relay information to and from the ground terminal. From the ground terminal, satellite and ground communica-

tion links interconnect the NASA elements of the network and any remotely located user facilities.

The fiscal year 1986 request includes funding for repayment of the loans extended by the Federal Financing Bank (FFB) for TDRSS development; payments to the TDRSS contractor for continuing TDRSS production, TDRSS services, and for maintenance and operation of the White Sands Complex; manpower and services necessary to operate and maintain the other NASA elements of the network; and systems engineering, engineering analyses and other support services to the network elements such as mission planning, logistics, and documentation.

The TDRS-1 was launched in April 1983, but due to an upper stage failure, TDRS-1 was delivered to an incorrect orbit. In late June 1983, the mission was recovered through a complex sequence of maneuvers and the spacecraft was placed into its nominal orbit. Since that time, the spacecraft has supported subsequent Shuttle missions, including Spacelabs and free-flyer missions, such as the Solar Maximum Mission, Earth Radiation Budget Experiment, Landsat, and Solar Mesospheric Explorer. Problems with the spacecraft timing circuitry led to cancellation of the second TDRS launch which was scheduled for early 1985. Modifications have been made to all remaining spacecraft to correct the problem. The second TDRS, however, was destroyed in the January 28, 1986 *Challenger* accident.

It is expected that TDRS-3 will be deployed on the first shuttle mission after shuttle flights resume. TDRS-4 delivery is anticipated in the fall of 1986, and TDRS-5 is expected to be available in late 1987.

NASA plans to procure a TDRS to replace the one lost in the *Challenger* accident, along with parts for a second spacecraft through a sole-source contract with the incumbent prime contractor. Delivery of the replacement spacecraft is scheduled for September 1991.

NASA will begin a TDRS follow-on study in late 1986, leading to a decision to procure competitively advanced, follow-on spacecraft, with deliveries planned to begin in 1996.

As of January 1, 1986, the ground network included the Spaceflight Tracking and Data Network (STDN), consisting of nine geographically dispersed ground stations which support Earth orbital missions; the Deep Space Network (DSN), consisting of three stations approximately 120 degrees apart in longitude for continuous mission viewing, which support planetary and solar system flight missions and some Earth orbital missions; and instrumentation facilities, both fixed and mobile, which support the Aeronautics, Balloon, and Sounding Rocket (AB&SR) programs.

Funds requested for the Communications and Data Systems program provide for the implementation and operation of facilities and systems which are required for data transmission, mission control, and data processing support.

COMMITTEE COMMENTS

The purpose of the Committee's additional authorization of \$62 million above the administration's request is to compensate for the

effects of the *Challenger* accident on NASA's tracking capabilities. With the loss of TDRS-2 in the *Challenger* accident, the TDRS systems will not be operational as soon as previously anticipated. Consequently, NASA will have to maintain its ground tracking stations (which would have been closed after deployment of the third TDRS) through fiscal year 1987 and, likely, beyond, at a cost of \$3 million to \$4 million per month.

This additional authorization is also designed to initiate the procurements of a TDRS satellite to replace the satellite destroyed in the accident. Because the replacement satellite for TDRS-2 is needed in 1992 to avoid a gap in tracking capabilities, NASA must initiate the procurement in fiscal year 1987.

CONSTRUCTION OF FACILITIES—\$161,300,000

The Committee authorizes \$161.3 million for Construction of Facilities, \$20.0 million below the administration's request. This authorization is for the purposes described below, and the \$20 million reduction is to be applied to these projects, at the discretion of NASA:

(1) Construction of addition to Orbiter Processing Facility Annex, John F. Kennedy Space Center, \$3,400,000; (2) Construction of addition to the Systems Integration and Mockup Laboratory, Johnson Space Center, \$5,000,000; (3) Construction of Central Computing Facility Johnson Space Center, \$9,000,000; (4) Modifications to Test Stand 300 for Space Station Hydrogen/Oxygen Propulsion Systems Development, George Marshall Space Flight Center, \$2,100,000; (5) Construction of Spacecraft Systems Development and Integration Facility, Goddard Space Flight Center, \$8,000,000; (6) Construction of Engineering Support Building, Jet Propulsion Laboratory, \$9,800,000; (7) Modification of Uninterruptible Power System in Space Flight Operations Facility, Jet Propulsion Laboratory, \$2,600,000; (8) Construction of Human Performance Research Laboratory, Ames Research Center, \$9,400,000; (9) Construction of Integrated Test Facility, Dryden Flight Research Facility, \$17,500,000; (10) Modifications to 8-foot High Temperature Tunnel, Langley Research Center, \$9,700,000; (11) Construction of addition for Non-Destructive Evaluation Research Laboratory, Langley Research Center, \$2,000,000; (12) Construction of Power Systems Facility, Lewis Research Center, \$5,800,000; (13) Construction of the Second Tracking and Data Relay Satellite System Ground Terminal Facility, New Mexico, \$22,000,000; (14) Repair of facilities at various locations, not in excess of \$750,000 per project, \$24,000,000; (15) Rehabilitation and modification of facilities at various locations, not in excess of \$750,000 per project, \$30,000,000; (16) Minor construction of new facilities and additions to existing facilities at various locations, not in excess of \$500,000 per project, \$7,000,000; and (17) Facility planning and design not otherwise provided for, \$14,000,000.

The Construction of Facilities (COF) appropriation provides for contractual services for repair, rehabilitation, and modification of existing facilities; the construction of new facilities; the acquisition of related facility equipment; the design of facilities projects; and advance planning related to future facilities needs.

The funds requested for 1987 provides for the continuation of prior years' endeavors in meeting the facilities requirements for space flight, modification of aeronautical research and development facilities; repair, rehabilitation, and modification of other facilities to maintain, upgrade, and improve the usefulness of the NASA physical plant; minor construction of new facilities; and facility planning and design. The projects and amounts in the budget estimate reflect Space Flight timing requirements.

The fiscal year 1987 program continues to preserve and enhance the capabilities and usefulness of existing facilities and to ensure safe and efficient use of the NASA physical plant. This request continues the necessary rehabilitation and modification program as in prior years and continues a repair program. The purpose of the repair program is to restore facilities to a condition substantially equivalent to their originally designed capability. The minor construction program provides a means to build smaller facilities to accommodate changes in technical and institutional requirements.

COMMITTEE COMMENTS

The Committee's reduction in funding of \$20 million below the administration's budget is amde without prejudice. However, the Committee recognizes the need for the Spacecraft System Development and Integration Facility (SSDIF) for Goodard Space Flight Center and the space program, especially for ground support for on-orbit servicing of the Hubble Space Telescope (HST). The Committee recommends that NASA keep the SSDIF facility on schedule and that every effort be made to have the HST infrastructure in place.

RESEARCH AND PROGRAM MANAGEMENT—\$1,425,000,000

The Committee authorizes \$1,425 million for Research and Program Management, \$16 million below the administration's request of \$1,441 million.

The Research and Program Management appropriation funds the performance and management of research, technology and test activities at NASA installations, and the planning, management and support of contractor research and development tasks necessary to meet the Nation's objectives in aeronautical and space research. Objectives of the efforts funded by the Research and Program Management appropriation are to (1) provide the civil service staff with the technical and management capability needed to conduct the full range of programs for which NASA is reponsible, (2) maintain facilities and manage their use in support of research and development programs, and (3) provide technical and administrative support for the research and development programs.

The 21,800 permanent and temporary civil service personnel at eight major installations and Headquarters are funded by the Research and Program Management appropriation. This civil service workforce is NASA's most important resource and is vital to future space and aeronautics research. About 70 percent of the Research and Program Management appropriation provides for salaries and related costs of this civil service workforce. Two percent is for travel, which is vital to managing NASA's in-house and contracted

programs. The remaining amount of the Research and Program Management appropriation provides for the research, test, and operational facility support, and for related goods and services necessary to operate the NASA installations and to accomplish NASA's approved missions.

COMMITTEE COMMENT

The Committee's \$16 million reduction in Research and Program Management is based on the anticipated reduction in overtime pay at Kennedy Space Center during fiscal year 1987. With a significantly reduced flight schedule at KSC during fiscal year 1987, the Committee believes that this reduction can be accommodated without otherwise affecting civil service pay.

ADDITIONAL COMMITTEE COMMENTS

LAUNCH POLICY

The January 28, 1986 accident of the space shuttle *Challenger* revealed the fragile nature of the U.S. space launch capability, notwithstanding the previous 24 successful Shuttle launches. In the aftermath of the *Challenger* accident, the vulnerabilities associated with the policy of complete reliance on a single launch system have become eminently clear. With a shuttle downtime of at least 2 years, and a requirement of at least 2 years to resurrect any previously existing expendable launch system (ELV) production lines, the U.S. space program is faced with a period of relative inactivity unlike any other since the inception of our space program 28 years ago.

The most immediate priority in reestablishing U.S. preeminence in space is to regain access to space via a robust and dependable launch capability. The United States cannot again afford to find itself incapable of gaining access to space for the length of time we are now experiencing. Accordingly, the Committee strongly supports the concept of a mixed fleet of space shuttles and ELV's and believes that the United States has no other options to consider. Alternate launch systems are critical to our national security and provide the launch flexibility which is essential for the conduct of an aggressive and balanced program of space exploration and development. The Committee recognizes, however, the definitional problems associated with the term, "mixed fleet", especially in terms of the nature of the ELV capability—whether it is commercial, national, or some combination of the two. Nevertheless, the Committee believes the U.S. space program must address this issue with the utmost urgency.

In addressing this issue, the Committee believes that we must consider the needs and requirements of all potential users—space science and applications, military, and commercial. The Committee notes, in particular, the unique advantages that ELVs provide for certain space science and applications missions, compared to manned launch systems. In certain cases, ELVs offer a more efficient and effective launch capability, and our national space science and applications programs, as well as the commercial and national security sectors, should be able to take advantage of and

benefit from the launch capability that best suits their individual needs. To that end, the Committee requests NASA to provide to the Committee no later than January 31, 1987, a plan which describes how NASA intends to utilize ELV launches for future civil launch requirements. This plan should discuss, but not be limited to, the availability of a commercial ELV capability, a NASA ELV capability, and a DOD ELV capability.

As for the administration's August 15 announcement that the shuttle would be precluded from launching private communications satellites after it honors its previously existing launch services agreements, the Committee recognizes that the intent of this policy is to establish a viable U.S. commercial ELV capability and believes that this goal is worthy of pursuit. The Committee notes, however, that this is only one of many goals that our space program should support. The Committee believes that another equally important goal is the commercial development of products and industries that require the unique capabilities of the space shuttle. The Committee is concerned that the administration's policy announcement holds the potential to affect adversely, albeit unintentionally, this and other goals of our space program.

The Committee notes that, in general, the prohibition of the shuttle from launching private communications satellites does remove from the world launch market a significant competitor—an action which could create a more favorable climate for the future of a U.S. commercial ELV industry. The Committee does not believe, however, that this action, in and of itself, will result in a U.S. commercial ELV industry that will be able to compete effectively against existing and anticipated foreign ELV systems.

The Committee has observed the growing interest of many nations in the world space launch industry. Even though the French Arianespace ELV is experiencing problems of its own, in its relatively brief existence Arianespace has been able to garner a significant share of the world launch market. Other nations—Japan, China, and the Soviet Union—are either in the process of developing their own commercial launch systems or have made marketing overtures to potential commercial customers. Foreign competition is a market force that we cannot ignore. Furthermore, the subsidized nature of these foreign launch systems will likely give these commercial entrants a distinct economic advantage over any U.S. commercial launch system which, by its very nature, will not be subsidized.

Since the inception of the "ELV commercialization" initiative in 1983, the Committee has supported the development of a viable U.S. commercial ELV industry and notes some early movement in this industry as a result of the current dislocation in our launch capability. The Committee also recognizes, however, that the future of this industry is uncertain and that the economic viability of U.S. commercial ELV systems is threatened by a number of risks, some of which are beyond the control of the U.S. ELV companies. With this in mind, the Committee believes that the U.S. space program should not unknowingly position itself so that it, in effect, hands over the world launch market to foreign competition. Furthermore, the Committee believes that the United States should not "burn its bridge" to the use of the Shuttle for foreign and commercial pay-

loads. If U.S. commercial ELV's turn out to be prohibitively expensive, or if foreign competition is such that U.S. ELV companies are unable to compete effectively, the shuttle should not be precluded from retaining for the United States its rightful share of this market.

The Committee does not oppose the August 15 launch policy announcement, but the Committee notes the incomplete nature of this policy and its lack of specificity. The Committee believes that this policy, as presented, raises too many unanswered questions. Furthermore, the Committee believes that as the administration clarifies and refines its August 15 announcement it should give serious consideration to the potential threat posed by foreign competition. We should seek a final policy that strikes a more reasonable balance between the goal of developing a viable U.S. commercial ELV industry and the goal of maintaining an effective and competitive U.S. presence in the world launch market.

Likewise, the Committee believes that the administration should seek to establish a pricing policy that allows the shuttle to remain an economically viable and competitive launch option for foreign and commercial payloads. The Committee again notes the subsidized nature of existing and anticipated commercial launch systems and believes that any shuttle pricing policy for commercial payloads should take this into consideration. On the other hand, the Committee believes that any shuttle pricing policy should not be fashioned in a manner that eliminates U.S. commercial ELV's as a viable and competitive launch option. Just as it is important for the United States to maintain its rightful share of the world launch market, it is equally important that we establish a robust and flexible launch capability that always ensures that U.S. civil, commercial, and national security payloads have access to space.

The Committee recognizes the difficulty and conflict in attempting to achieve the goals of establishing a viable domestic commercial ELV industry and that of ensuring a rightful U.S. share of the world launch market. Nevertheless, the Committee encourages the administration to develop a pricing policy that balances these goals and interests in a manner that satisfies not only our Nation's space objectives, but also those of our Nation as a whole.

The Committee believes that the administration, in defining this new launch policy, should give careful consideration to shuttle-unique technologies and the investment they represent. In doing so, the administration should minimize the adverse effect that this policy could have on companies that have made significant investments in shuttle-unique technologies.

Also, the Committee believes that the current pricing policy with DOD should be reconsidered in light of several post-*Challenger* events. DOD's relative and absolute use of the shuttle, compared to its previously anticipated use, will increase. Also, the "mothballing" of the shuttle launch complex at Vandenberg Air Force Base calls into question the "quid pro quo" element of the current NASA/DOD shuttle pricing policy. Finally, the uncertainties associated with the DOD reimbursables to NASA in the fiscal year 1987 DOD budget raise additional questions about the relevance of the current NASA/DOD shuttle pricing policy. Therefore, the Committee encourages the administration to reexamine this policy to

ensure that the operant policy truly reflects the new environment in which our space program exists.

REPLACEMENT ORBITER

Section 10 of S. 2714, as reported by the Committee, authorizes the construction of a replacement orbiter in fiscal year 1987 if the President makes such a recommendation and if funds are made available in addition to those provided in the bill.

The administration's August 15 formal recommendation for a replacement orbiter was a long-overdue announcement. The delay in this announcement of 6½ months from the *Challenger* accident has created unnecessary confusion, disarray, and uncertainty in our civilian space program. A more timely announcement would have enabled all sectors of our space program to plan and prepare more efficiently and effectively. Nevertheless, the Committee fully endorses the administration's recommendation to replace the *Challenger*. Even with the prospect of a growing expendable launch vehicle capability, a three-orbiter fleet would have left the United States with, at best, a marginal space transportation system.

According to testimony before the Committee from all sectors of our national space program, a four-orbiter fleet is crucial for the timely deployment of civil payloads, the construction and servicing of the space station, and the accomplishment of national security missions. Because national launch priorities permit national security payloads to preempt all other payloads, the beneficiaries of a four-orbiter fleet are the civilian scientific and commercial R&D payloads whose launch might otherwise be even further delayed or eliminated from the shuttle manifest.

The Committee believes that even with an enhanced ELV capability, a three-orbiter fleet will be stressed in its attempts to work off the backlog of payloads resulting from the *Challenger* accident and, simultaneously, to launch with minimal delay the payloads that were previously scheduled for launch between 1988 to 1992. Also, the shuttle fleet of the future will operate under different constraints than in the past. There will be more consideration given to safety, launch readiness of the orbiter, and the capabilities of the personnel associated with each launch. Consequently, the launch rate of each orbiter will be less ambitious than previously anticipated.

Finally, a four-orbiter fleet is important as a form of insurance, should any single orbiter be taken out of service. With a three-orbiter fleet, a reduction of the fleet size to two orbiters, even if temporary, would adversely affect the whole breadth of our space program and reduce our space launch capability to an unacceptable and precarious level.

For the reasons mentioned above, the Committee enthusiastically supports the replacement of the *Challenger* as a necessary measure to restore our space program to a competitive position and to maintain an aggressive and balanced space program.

As for the administration's plan to fund the replacement orbiter and the inertial upper stage cradle, the Committee is concerned over its lack of specificity. Although the budget authority for the replacement of the orbiter and IUS cradle is largely "new" budget

authority, there has been no clear identification of the source of the appropriated funds, or outlays.

Furthermore, there appears to be no understanding within the administration as to the source of funds that will be required in fiscal year 1988 through fiscal year 1991. The Committee believes that this is not a funding obligation that NASA should bear at the expense of its current or anticipated programs. The Committee believes that the only appropriate manner in which to fund these replacements is for the administration to accommodate in each budget year the required funding over and above NASA's baseline funding. The effects of the *Challenger* accident on NASA's budget and programs have already been far too disruptive; for NASA to accept these additional budget requirements within the context of budgets that do not grow accordingly is destructive and indefensible.

NATIONAL AERONAUTICS AND SPACE COUNCIL

Section 11 of S. 2714, as reported by the Committee, authorizes the reestablishment, within the Executive Office of the President, of the National Aeronautics and Space Council (NASC). The NASC would be composed of the Vice President, who would serve as Chairman, the NASA Administrator, and the Secretaries of Transportation, Defense, Commerce, and State. Among the major functions of the NASC would be to assist in the formulation of aeronautical and space policy and to resolve interagency disputes concerning aeronautical and space issues.

The Committee has been deeply concerned about the efficacy of the Senior Interagency Group (SIG) on Space in making the crucial decisions related to our national space recovery plan. The Committee believes that the 6½ month delay in the administration's formal announcement to replace the *Challenger* and to formulate a new launch policy was inexcusable. Rather than moving crisply into a meaningful space recovery plan, our space program was held captive by the protracted debate and interagency disputes of the SIG on Space. The Committee recognizes that the problems that resulted from the *Challenger* accident were by far the most complex that our space program has ever faced; yet, for that very reason, these issues begged for a more timely resolution than they received.

Furthermore, the Committee believes that the SIG on Space has been deficient in keeping the Committee informed as to the options under considerations during its deliberations. The Committee recognizes that the issues under consideration have national security implications. Nevertheless, a more willing and open form of communication over the past 6½ months from the SIG on Space and the Committee was a reasonable expectation and could have facilitated and expedited the resolution of some of the issues at hand.

For these reasons, the Committee believes that there should be another executive branch forum in which aeronautical and space issues can be discussed and resolved. The Committee believes that the NASC is a highly appropriate forum. The Committee expects that the NASC will resolve aeronautical and space issues in a more

timely and appropriate manner and will communicate more freely and regularly with Congress in the resolution of these issues.

In addition, the Committee believes that a NASC could elevate aeronautical and space issues to a higher national profile and, thereby, establish a higher national priority for these issues.

The Committee recognizes that the reestablishment of the NASC will not, in and of itself, reform the manner in which aeronautical and space issues are addressed and resolved. The individuals associated with the NASC, and not the institutional structure of the NASC itself, will largely determine the efficacy of the NASC. Nevertheless, the Committee believes that reestablishing the NASC is a step in the right direction for ensuring that the U.S. program recovers from the *Challenger* accident and proceeds to a capability that is sufficient to meet the demands and expectations of the 21st century.

INTERNATIONAL SPACE YEAR

The 1986 NASA authorization bill included a request that NASA initiate interagency and international discussions to explore the opportunities for an International Space Year (ISY) in 1992 and that, no later than May 1986, the President submit a report to Congress on progress toward an ISY.

The report from the President has been submitted. It notes that NASA found "overwhelmingly positive" support from foreign governments for an ISY, as well as from other U.S. agencies and national and international nongovernmental organizations. It supports NASA recommendations that the United States "pursue the establishment of an International Space Year . . . through appropriate fora such as the Committee on Space Research (COSPAR), its parent body the International Council of Scientific Unions (ICSU), and the International Astronautical Federation (IAF)." The report also supports NASA recommendations that the United States National Academy of Sciences (NAS) "play a key role in focusing discussion within the United States scientific community regarding the scientific content of an ISY and in carrying the United States proposal to the appropriate international scientific bodies."

In response to the President's directive, the National Academy of Sciences delegation to the annual meeting of COSPAR in July 1986 supported a successful resolution calling for COSPAR to establish a committee to "develop plans for the scientific components of an International Space Year in 1992 . . . (and) receive suggestions from all national agencies, scientific academies and scientific societies concerned with the ISY." In addition, the American Institute of Aeronautics and Astronautics (AIAA) delegation to the IAF annual meeting in October is planning to raise the ISY issue.

The Committee applauds the leadership shown by the President and by NASA in advancing the ISY, as well as the course pursued by NAS and AIAA so far. The Committee urges NASA to intensify its efforts on behalf of an ISY and to support viable ISY initiatives undertaken by NAS, AIAA, and other agencies NASA deems appropriate vehicles for organizing U.S. participation in the ISY and for advancing the ISY in international fora. Such support may include modest appropriations for administrative purposes.

If the ISY is to be successful, administrative structures must be established within the next 12 months. Therefore, the Committee requests that NASA report to the Congress, no later than May 1987, on the progress made in its intensified efforts to establish administrative structures for an ISY, involving appropriate governmental and nongovernmental organizations.

ESTIMATED COSTS

In accordance with paragraph 11(a) of rule XXVI of the Standing Rules of the Senate and section 403 of the Congressional Budget Act of 1974, the Committee provides the following cost estimate, prepared by the Congressional Budget Office:

U.S. CONGRESS,
CONGRESSIONAL BUDGET OFFICE,
Washington, DC, September 9, 1986.

Hon. JOHN C. DANFORTH,
Chairman, Committee on Commerce, Science and Transportation,
U.S. Senate, Washington, DC.

DEAR MR. CHAIRMAN: The Congressional Budget Office has prepared the attached cost estimate for S. 2714, the National Aeronautics and Space Administration Act, 1986.

If you wish further details on this estimate, we will be pleased to provide them.

With best wishes,

Sincerely,

RUDOLPH G. PENNER, *Director.*

CONGRESSIONAL BUDGET OFFICE COST ESTIMATE

1. Bill number: S. 2714.
2. Bill title: National Aeronautics and Space Administration Act, 1986.
3. Bill status: As amended and ordered reported by the Senate Committee on Commerce, Science and Transportation, August 14, 1986.
4. Bill purpose: This bill authorizes the appropriation of \$7,795 million for the National Aeronautics and Space Administration (NASA) and about \$2.3 million for the Office of Commercial Space Transportation within the Department of Transportation for fiscal year 1987. The bill also reestablishes the National Aeronautics and Space Council.

The authorization includes \$3,096 million for space flight, control, and data communications and \$3,112.7 million for research and development, including \$400 million for the space station. The bill also includes \$161.3 million for construction of facilities and \$1,425 million for research and program management. The total amount authorized is \$101 million above the President's fiscal year 1987 budget request and about \$31 million above the fiscal year 1986 NASA appropriation after adjustment for the Balanced Budget Act reductions and supplemental appropriations.

In addition to the specific funding authorizations, the bill also authorizes NASA to construct a fourth space shuttle orbiter if the President determines that a fourth orbiter is in the national inter-

est and funds are made available for construction in addition to funds authorized by this bill. CBO's current estimate of the cost of a new orbiter is about \$2.2 billion, assuming construction begins in 1987 and occurs over a six-year period. (Costs could differ depending on the length of the construction period.)

5. Estimated cost to the Federal Government: The following table shows funding amounts specially authorized by S. 2714 and estimated outlays based upon those amounts.

[By fiscal years, in millions of dollars]

	1987	1988	1989	1990	1991
Specified authorization levels:					
Function 250: Civilian space	7,099.6				
Function 400:					
Aeronautics	695.4				
Commercial space	2.3				
Total specified authorizations	7,797.3				
Estimated outlays	5,115	2,158	497	23	4

In addition, the estimated authorization levels and outlays associated with the construction of a new space shuttle orbiter would be as follows:

[By fiscal years, in millions of dollars]

	1987	1988	1989	1990	1991
Estimated authorization—4th shuttle orbiter:					
Estimated authorization level	250	700	725	450	75
Estimated outlays	150	594	711	520	184

Note: The costs of this bill fall within budget functions 250 and 400.

Basis of estimate: The authorization levels in the first table are those specified in the bill. The outlay estimates assume that all funds authorized will be appropriated prior to the beginning of fiscal year 1987 and that spending will reflect historical patterns.

The authorization level and outlays for the fourth shuttle orbiter are CBO estimates based upon data provided by NASA. CBO assumes that all funds estimated to be necessary will be appropriated prior to the beginning of the fiscal year in which they are required. Outlay estimates assume that spending will reflect historical patterns for orbiter production. In addition to those amounts shown in the table, CBO estimates a fiscal year 1992 authorization level of \$40 million and outlays of \$80 million over fiscal years 1992 through 1994.

6. Estimated cost to State and local governments: None.

7. Estimate comparison: None.

8. Previous CBO estimate: None.

9. Estimate prepared by: Paul M. DiNardo.

10. Estimate approved by: James L. Blum, Assistant Director for Budget Analysis.

REGULATORY IMPACT STATEMENT

In accordance with paragraph 11(b) of rule XXVI of the Standing Rules of the Senate, the Committee provides the following evaluation of the regulatory impact of the legislation.

This bill authorizes the appropriation of funds for the conduct of space and aeronautical research and development activities to carry out the policy and purpose of the National Aeronautics and Space Act of 1958. These activities are conducted in NASA laboratories by NASA personnel and through contracts with industry, universities, and research institutions for research and development and for supporting scientific and technical services. The Committee has concluded the nature of these activities is such that there is no regulatory effect on individuals and businesses and no effect on individual privacy.

SECTION-BY-SECTION ANALYSIS

SECTION 1.

The first section states the short title of the bill, the "National Aeronautics and Space Administration Authorization Act, 1987."

SECTION 2.

An authorization of appropriations of \$7,795 million is provided as follows:

- a. \$3,112.7 million for "Research and Development";
- b. \$3,096 million for "Space Flight, Control, and Data Communications";
- c. \$161.3 million for "Construction of Facilities";
- d. \$1,425 million for "Research and Program Management".

SECTION 3

Authorization is provided for an increase in the "Construction of facilities" funds of up to 10 percent, at the discretion of the NASA Administrator, or 25 percent, following a report, to the Senate and House authorization committees justifying the increase.

SECTION 4

Up to one-half of 1 percent of the funds appropriated for "Research and development" and "Space flight, control, and data communications" may be transferred to "Construction of facilities." This amount then may be added together with \$10 million of the "Construction of facilities" appropriations for additional construction of facilities and land acquisition, if the NASA Administrator justifies the expenditure.

SECTION 5

No appropriations may be used for any program deleted by Congress and no appropriations may exceed the amount authorized for that particular program. For NASA to obtain funding for programs not presented to the Senate and House in the routine manner, NASA must first prepare a report justifying the proposal. Then, 30

days must elapse after receipt by the Senate and the House of this report.

SECTION 6

The civil space station may not be used to carry or to deploy in space nuclear weapons or any other weapon of mass destruction.

SECTION 7

Consideration shall be given to geographical distribution of Federal research funds whenever feasible.

SECTION 8

This section amends section 24 of the Commercial Space Launch Act (Public Law 98-575) to authorize \$2.275 million to the Office of Commercial Space Transportation of DOT.

SECTION 9

This section directs the NASA Administrator to review the report of the National Commission on Space and, by March 1, 1987, recommend to the relevant committees an implementation plan and a specific agenda for the next 5 years.

SECTION 10

This section authorizes the construction of a replacement orbiter if the President makes the recommendation to do so and if the funds are appropriated in addition to those provided by this act.

SECTION 11

This section establishes in the Executive Office of the President a NASC, to be chaired by the Vice President. The other members would be the NASA Administrator, and the Secretaries of Defense, State, Commerce, and Transportation. The purpose of this Council is to assist in the formulation of aeronautical and space policy and to resolve in a timely manner interagency disputes on aeronautical and space issues.

SECTION 12

This section directs the NASA to include as separate line item in its annual budget submitted by the President the estimated expenditures and proposed appropriations necessary to carry out its functions relating to quality assurance, reliability, and safety.

SECTION 13

This section provides that it is the sense of the Senate that no bill, resolution, or amendment to deplete Conrail cash be considered by the Senate until the Senate Commerce Committee has reviewed the effect of such a proposal on the sale of Conrail.

ROLLCALL VOTES IN COMMITTEE

In accordance with paragraph 7(c) of rule XXVI of the Standing Rules of the Senate, the Committee provides the following record votes during its consideration of S. 2714:

On amendment in the nature of a substitute offered by Senator Pressler:

YEAS—9

Mr. Pressler
Mr. Hollings
Mr. Long ¹
Mr. Inouye ¹
Mr. Ford ¹
Mr. Riegle
Mr. Exon ¹
Mr. Gore
Mr. Rockefeller

NAYS—8

Mr. Danforth
Mr. Packwood ¹
Mr. Goldwater ¹
Mrs. Kassebaum ¹
Mr. Gorton
Mr. Stevens
Mr. Kasten ¹
Mr. Tribble ¹

¹ By proxy.

On amendment offered by Senator Pressler expressing the sense of the Senate regarding the cash balance retained by the Consolidated Rail Corporation:

YEAS—9

Mr. Pressler
Mr. Hollings
Mr. Long ¹
Mr. Inouye ¹
Mr. Ford ¹
Mr. Riegle
Mr. Exon ¹
Mr. Gore
Mr. Rockefeller

NAYS—8

Mr. Danforth
Mr. Packwood ¹
Mr. Goldwater ¹
Mrs. Kassebaum ¹
Mr. Gorton
Mr. Stevens
Mr. Kasten ¹
Mr. Tribble ¹

¹ By proxy.

On amendment offered by Senator Riegle to increase funding for space shuttle production and operational capability:

YEAS—8

Mr. Hollings
Mr. Long ¹
Mr. Inouye ¹
Mr. Ford ¹
Mr. Riegle
Mr. Exon ¹
Mr. Gore
Mr. Rockefeller

NAYS—9

Mr. Danforth
Mr. Packwood
Mr. Goldwater ¹
Mrs. Kassebaum
Mr. Pressler
Mr. Gorton
Mr. Stevens ¹
Mr. Kasten ¹
Mr. Tribble ¹

¹ By proxy.

On amendment offered by Senator Riegle regarding construction of a replacement orbiter:

YEAS—8

Mr. Hollings
Mr. Long

NAYS—9

Mr. Danforth
Mr. Packwood ¹

Mr. Inouye ¹
 Mr. Ford ¹
 Mr. Riegle
 Mr. Exon ¹
 Mr. Gore
 Mr. Rockefeller

Mr. Goldwater ¹
 Mrs. Kassebaum ¹
 Mr. Pressler
 Mr. Gorton
 Mr. Stevens ¹
 Mr. Kasten ¹
 Mr. Tribble

¹ By proxy.

On amendment offered by Senator Gore regarding reprisals against employees for disclosure of violations of law, mismanagement, or similar circumstances:

YEAS—8

Mr. Hollings
 Mr. Long
 Mr. Inouye ¹
 Mr. Ford ¹
 Mr. Riegle
 Mr. Exon ¹
 Mr. Gore
 Mr. Rockefeller

NAYS—9

Mr. Danforth
 Mr. Packwood
 Mr. Goldwater ¹
 Mrs. Kassebaum
 Mr. Pressler
 Mr. Gorton
 Mr. Stevens ¹
 Mr. Kasten ¹
 Mr. Tribble ¹

¹ By proxy.

CHANGES IN EXISTING LAW

In compliance with paragraph 12 of rule XXVI of the Standing Rules of the Senate, changes in existing law made by the bill, as reported, are shown as follows (existing law proposed to be omitted is enclosed in black brackets, new material is printed in italic, existing law in which no change is proposed is shown in roman):

THE NATIONAL AERONAUTICS AND SPACE ACT OF 1958

Section 201 of that Act

SEC. 201. (a) There is hereby established, in the Executive Office of the President, the National Aeronautics and Space Council (hereinafter called the "Council") which shall be composed of—

- (1) the Vice President, who shall be Chairman of the Council;
- (2) the Secretary of State;
- (3) the Secretary of Defense;
- (4) the Secretary of Transportation;
- (5) *the Secretary of Commerce; and*

[(5)] (6) the Administrator of the National Aeronautics and Space Administration [; and].

[(6)] the Chairman of the Atomic Energy Commission.]

(b) * * *

[(c) Each member of the Council may designate another officer of his department or agency to serve on the Council as his alternate in his unavoidable absence.]

[(d)] (c) Each alternate member designated under subsection [(c)] (b) of this section shall be designated to serve as such by and with the advice and consent of the Senate unless at the time of [his] *such member's* designation [he] *the member* holds an office

in the Federal Government to which [he] *the member* was appointed by and with the advice and consent of the Senate.

[(e) (d)] It shall be the function of the Council to advise and assist the President, as [he] *the President* may request, with respect to the performance of functions in the aeronautics and space field, including the following functions:

(1) survey all significant aeronautical and space activities, including the policies, plans, programs, and accomplishments of *United States, Including* all departments and agencies of the United States engaged in such activities, *and other nations*;

(2) develop a comprehensive program of aeronautical and space activities to be conducted by departments and agencies of the United States;

(3) designate and fix responsibility for the direction of major aeronautical and space activities;

(4) provide for effective cooperation among all departments and agencies of the United States engaged in aeronautical and space activities, and specify, in any case in which primary responsibility for any category of aeronautical and space activities has been assigned to any department or agency, which of those activities may be carried on concurrently by other departments or agencies; and

(5) resolve differences arising among departments and agencies of the United States with respect to aeronautical and space activities under this Act, including differences as to whether a particular project is an aeronautical and space activity.

[(f)] (e) The Council may employ a staff to be headed by a civilian executive secretary who shall be appointed by the President by and with the advice and consent of the Senate. The executive secretary, subject to the direction of the Council, is authorized to appoint and fix the compensation of such personnel, including not more than seven persons [who may be appointed without regard to the civil service laws or the Classification Act of 1949 and compensated at not to exceed the highest rate of grade 18 of the General Schedule of the Classification Act of 1949, as amended], as may be necessary to perform such duties as may be prescribed by the Council in connection with the performance of its functions. Each appointment under this subsection shall be subject to the same security requirements as those established for personnel of the National Aeronautics and Space Administration appointed under section [203(b)(2)] 203(c)(2) of this Act. Other provisions of law or regulations relating to Government employment [(except those relating to pay and retirement)] shall apply to [council employees] *Employees of the Council* reporting directly to the [chairman] *Chairman* to the extent that such provisions are applicable to employees in the Office of the Vice President.

THE COMMERCIAL SPACE LAUNCH ACT

Section 24 of that Act

AUTHORIZED APPROPRIATIONS

SEC. 24. There are authorized to be appropriated to the Secretary \$4,000,000 for fiscal year 1985. There is authorized to be appropriated to the Secretary to carry out this Act \$586,000 for fiscal year 1986. *There is authorized to be appropriated to the Secretary to carry out this Act \$2,275,000 for fiscal year 1987.*

ADDITIONAL VIEWS OF MR. PRESSLER

EARTH SYSTEM SCIENCE STUDY

I am very pleased that the Committee has adopted my suggestion to study the feasibility and advisability of establishing a formal Earth System Science Program, and specifically to address the advisability of establishing a National Institute for Earth Systems Science Studies. The majority views accurately reflect the desired goals and parameters of this inquiry. I write separately to provide a fuller understanding of and insight into my thoughts on this issue.

BACKGROUND

Scientific research has revealed a tremendous amount of information about the Earth. We now possess a panoply of detailed and exhaustive data about the continents, oceans, atmosphere and biosphere. But this research, while revealing many of the details of the various components of the Earth, has also shown us that they are merely parts of an extremely dynamic and complex Earth system—which we still understand very poorly. Many physical, chemical and biological processes which operate on a regional, continental or global scale are profoundly affected (often unwittingly) by the acts of man. If we are to control our destiny on this planet, we must better understand the Earth as a whole—as a system with many complex, wide-ranging and interacting components.

We know that in some parts of the world deserts are expanding, tropical forests are decreasing, and ice caps are changing in size. We suspect that these changes may affect or be affected by global atmospheric and oceanic phenomena in ways that we do not fully understand. We see atmospheric carbon dioxide increasing and ozone decreasing, lakes and forests adversely affected by acid rain, and both droughts and floods concurrently resulting from, we think, the "El Niño" phenomenon. Genetic diversity is decreasing, wildlife species are becoming extinct or endangered, topsoil is eroding, and estuaries are deteriorating. In many cases we neither understand nor can control these changes.

Thus, while scientific research has substantially improved our understanding of our world, and has provided insights for improving the quality of our environment, it has also opened our eyes to how little we really understand the fundamental global-scale Earth systems that shape our lives.

Fortunately, recent technological advancements in our space program—particularly the new and planned land resources, oceanic and atmospheric remote sensing satellites—are beginning to pro-

vide us tools to observe, measure, analyze and evaluate these Earth systems

THE PROPOSED PROGRAM

In recent years, a number of programs, such as Man in the Biosphere, Global Habitability, and Land Surface Climatology, have been initiated that would begin to look at the Earth as a system, and to gather and analyze various types of data on a global scale. In general, however, these programs have dealt with particular components of the Earth system (e.g., the climate, the biosphere, or geologic processes) and are generally not well coordinated or integrated with one another. The Earth System Science Study recently submitted to NASA by its Advisory Council,¹ on the other hand, has proposed a program that would begin to meet the challenge of understanding the entire Earth system on a global scale. Its goal is to help describe how the component parts of the Earth system and their interactions have evolved, how they function, and how they may be expected to evolve in the future. Eventually, it is hoped that this program will assist us in predicting changes that will occur over the next decades and centuries—both naturally and in response to human activity. We would then possess knowledge and information that would permit much more informed and rational planning of man's activities as they affect global habitability.

The Earth System Science Program proposes for the next decade a number of activities that will begin to provide a data base for Earth System Science studies. These elements are: (1) continued operational space observations; (2) specialized space research missions; (3) basic research and in situ observations; (4) an advanced information system; and (5) instrument development. An advanced information system will provide worldwide access to data, process the extensive global data sets to be collected in the future, and facilitate data analysis and interpretation by the scientific community. Among the specific requirements are: data directories and catalogs, browse capabilities, and full data set documentation; the provision of computer facilities for high-level data processing; and the linking of local workstations with data access and control centers to facilitate investigator requests for specialized observations. This program, while under the general administration, direction, and leadership of NASA, must by necessity involve a number of other Federal agencies, including the National Oceanic and Atmospheric Administration [NOAA], the U.S. Geological Survey [USGS], the National Science Foundation [NSF], and others. In addition, international cooperation will be essential, and so the program must collaborate with many major international programs such as the World Climate Research Program, the International Geosphere-Biosphere Program, the Global Ocean Flux Study, and the Global Environmental Monitoring System of the United Nations.

¹ Earth System Science Committee, NASA Advisory Council, 1986. *Earth System Science Overview: A Program for Global Change*. National Aeronautics and Space Administration (Washington, DC, May 1983).

THE NATIONAL INSTITUTE FOR EARTH SYSTEM SCIENCE STUDIES

Given the scope and complexity of our information needs and the scale of the program described above, it is obvious that among the principal challenges in conducting a global-scale research activity are coordination, organization, and timely dissemination of results. Modern technology has, in general, provided us with means for collecting a variety of data in quantities sufficient to answer many critical global-scale questions. However, unless these data are well organized and readily available to all who might contribute their expertise to the program, in a format that many can readily use, and unless the collection of data is coordinated to prevent duplication of effort while ensuring adequate data acquisition, much of the potential effectiveness of the program will not be realized. Likewise, research findings, as well as the scientific methods used in the investigations, must be disseminated in a timely fashion to facilitate efficient science and avoid duplication of effort.

Thus, it is proposed that NASA establish a National Institute for Earth System Science Studies [NIESS] that would jointly involve NASA, NOAA, USGS, and the NSF. NASA is responsible for general research and development in civilian satellite technology; NOAA is responsible for operational weather, ocean and land satellites, and for collection of data pertaining to the atmosphere and oceans; and the USGS is responsible for collecting, organizing, and interpreting information about energy, minerals, water, and land resources. The role of the NSF must be to continue to promote and support studies in basic science and engineering, including those using satellite and complementary ground measurements, as well as large-scale field studies critical to successful global investigations. This Institute would provide a facility (including a core staff of scientists), advanced computer processing equipment, linkages to other major computational facilities, and laboratory space that would facilitate cooperative Federal research studies of global system processes. Its primary role would be not to control or direct all studies, but rather to facilitate and support certain of the most critical research efforts. It would be fully coordinated with other R&D programs, both national and international.

The Institute would provide researchers ready access to a wide variety of global data, including but not limited to land satellite remote sensing data, meteorological satellite data, oceanographic data, climatic data, Earth science data and digital cartographic data. It would provide a tie between academic, Federal Government agencies, and the international scientific community. Through the Institute, opportunities for conducting research would be made available to experts from around the world. It would also provide an advanced computerized information system. It would provide mechanisms to expedite the acquisition and processing of Earth observation data, and would create interfaces with existing archives for rapid and timely access to data. The Institute would serve as a focal point for conferences and symposia regarding Earth system studies and would facilitate the reporting process, both to NASA and to Congress.

The Institute's program would include at least the following critical ingredients: it would (1) lay a foundation for a long-term coop-

erative Federal research program; (2) develop advanced information systems for storing, processing and analyzing the massive amounts of data currently available in existing Earth science and remote sensing data archives; (3) be a joint effort between the leading civilian U.S. Earth science organizations; and (4) ensure international cooperation.

This Institute obviously would not be the only research facility involved in these studies, but it would provide a focal point for the coordination and dissemination of results of the program. The technical and scientific staff of the the Institute would provide a necessary core of interdisciplinary expertise. Scientific staffing would initially involve scientists and engineers from NASA, NOAA, and USGS, as well as other Federal, academic, and private organizations. Advanced data processing, data analysis, and mathematical modeling capabilities, laboratory equipment, and library facilities would be available at the Institute for use by cooperating scientists.

The Institute would be administered and technically directed by an advisory council consisting of representatives of the various participating Federal and international agencies and financially supported by NASA, NOAA, USGS and the NSF.

SUMMARY

It has become obvious that if we are to understand fully the global processes affecting and being affected by mankind, and to influence man's activities so as to enhance global habitability for ourselves and future generations, a well-coordinated program of Earth System Science Studies must be undertaken.

The NASA Earth System Sciences Committee has proposed an ambitious program of worldwide data collection and research that would begin to provide information on some of the complex global processes affecting our lives. This program, supervised by NASA, would involve a number of U.S. Federal agencies as well as international organizations and programs.

In order to provide appropriate and necessary coordination, support, and facilities for such a program, ANIESS should be established. This Institute would provide a core scientific staff, advanced information system management and planning, computerized data base archives and access, and a focal point for global process studies. As such, the Institute would contribute immeasurably to improving our knowledge and understanding of the Earth as a dynamic and integrated system.

These are the reasons I have proposed that the Committee direct NASA, working with NOAA, USGS and the NSF, to prepare and present to the Committee by June 1, 1987, the study outlined above. The ultimate goal toward which we are striving represents an ambitious undertaking. But I believe that its potential benefits justify the effort. I look forward to the results of this initial study with great interest.

LARRY PRESSLER.

ADDITIONAL VIEWS OF MESSRS. HOLLINGS, RIEGLE, GORE, AND ROCKEFELLER

On January 28, 1986, the Nation's space program was dealt a severe blow when the shuttle *Challenger* exploded. Lost in the accident were seven space pioneers, the image of NASA as a "Can Do—Safety First" agency, and the foundations of our national space program—civil, defense and commercial.

It has been over 7 months since the tragedy. During that period the Nation's space program, space policies, and space policymaking apparatus have been openly and severely criticized. It has become clear that all was not well within NASA nor with our national space policy in the days and months preceding the *Challenger* accident. Sole reliance upon the shuttle was not in the national interest, and the proposed shuttle flight rate and schedule were overly optimistic. Due to budgetary pressures and White House policy proclamations, the shuttle was being treated as a commercial airliner and the space program was being forced prematurely into a commercial mode of operations, a mode that was inimical to NASA. In its efforts to achieve these unreasonable goals with unreasonable levels of resources, NASA began to compromise the standards that had been the hallmark of the agency—safety, reliability, and quality assurance. The end result was a national tragedy!

In the aftermath of this disaster, many persons have tried to determine why the accident occurred and how such a set of circumstances managed to exist within NASA. To this day, many of the answers to these questions have not been provided. Part of the reason for this is that not all of the appropriate questions have been asked. Another part of the problem is that the answers that were given were not thorough and there was inadequate follow-up questioning. The work of the Rogers Commission is laudable at determining the cause of the accident. But even the Rogers Commission didn't answer all the questions.

Even within the ranks of the Senate Commerce Committee, there was considerable disagreement as to the appropriate procedure for the Subcommittee on Science, Technology, and Space to pursue in an attempt to answer these pressing questions in order to understand better the events leading up to the accident and its cause. Some members wanted the Committee to investigate the accident in a manner similar to the Apollo accident investigation, a separate Senate investigation that was complementary to the executive branch investigation, whereas other members wanted to leave the investigation totally to the Rogers Commission. Unfortunately, the end result of the Committee stalemate over the appropriate course of action to pursue is a Committee less well informed than it should be about critical space policy issues and the shuttle program.

In light of the events of the past year, it is now clear that the space program is at its most critical juncture in its history. The crisis for the civilian space program could not have occurred at a worse time. The pressure to balance the budget, the threat of foreign competition, the mergence and dominance of the defense space program, the proliferation of Federal agencies involved with and in space programs, the desire to commercialize space activities—all make it most difficult to formulate a clear, precise, pragmatic national space policy and to put NASA back on its feet and back on course.

The proclamations that have been made by the White House since the accident have been piecemeal and have lacked any detailed justification or rationale. Take the most recent, long awaited announcements concerning the administration's support of a new orbiter and its decision to preclude the launch of foreign and commercial satellites on the shuttle. Rather than resolve the outstanding issues, the announcements resulted in more questions than answers and even more confusion. Quite clearly, this course of events and this decisionmaking process cannot be allowed to continue. It is not in the best interest of the space program, NASA or the Nation.

It is for that Senators Riegle and Hollings introduced S. 2473 on May 20th, and act that would reestablish the National Aeronautics and Space Council in the White House to formulate aeronautics and space policy. At the most critical juncture, there was no room for interagency squabbles and turf fights as currently exist in the Senior Interagency Group for Space [SIG Space]. What is required is a new institution, the Space Council, that could address the difficult issues concerning the future scope and direction of the Nation's space program.

We are pleased that legislative language recreating the Space council has been included in S. 2714, as reported by the Committee. The reestablishment of the National Aeronautics and Space Council is an important step in the reconstitution of the Nation's space program.

There is no way to underestimate the impact of chapter VII of the Rogers Commission Report entitled "The Silent Safety Program." To discover that the interdependent safety program that resulted in the Apollo successes had little or no role in the space shuttle program is cause for serious concern and inquiry. As a first step in correcting these flaws, NASA is implementing the recommendations of the Rogers Commission and has already appointed a new Associate Administrator for Safety, Reliability, and Quality Assurance. We support these actions. However, despite the support for such a new office, the office in and of itself is not a panacea. Safety must be the priority of each and every NASA and contractor employee if the shuttle success rate is to be comparable with the Apollo success rate. We must increase the number of inspectors and the amount of resources available for the new Associate Administrator of Safety, Reliability, and Quality Assurance, but these actions in and themselves are not enough to improve the overall level of safety. To be frank, we differ among ourselves as to the best way to reestablish a viable safety program in NASA. But we are in total agreement with the fact that safety, reliability, and

quality assurance must become the hallmarks of NASA. Along those lines, we are pleased that NASA will be required to include safety operations as a separate line item in the budget submitted by the President. This initiative, promoted by Senator Gore, is a step in the right direction. But more steps will be required if a safe, reliable shuttle system is to be put back into operation.

Along these lines we would like to indicate that we were displeased with the fact that the Committee failed to approve an amendment to S. 2714 that would have provided an additional \$100 million to implement the recommendations of the Rogers Commission. These funds would have accommodated additional testing on the solid rocket booster and would have provided NASA with the necessary resources to implement some new safety systems if supported by current analysis. If there is one lesson to be learned from the shuttle tragedy and the Rogers Commission Report, it is that some activities cannot be overemphasized in the budget, most notably safety and testing. The money you save today could result in an accident or system failure whose cost would greatly overshadow the savings. At this point in time, the Committee must tell NASA and the Nation that the necessary moneys will be provided to fix the shuttle and to thoroughly evaluate all of the systems, hardware, and safety procedures used on the shuttle. It might be more appealing to fund new starts and new programs like the space station. But without the shuttle—a safer, more reliable shuttle—it is quite clear that the civilian space program would be crippled for many years to come.

We are also disappointed that, in the Committee's consideration of the fiscal year 1987 NASA Authorization bill, the Committee was unwilling to authorize funds for the construction of a new orbiter. The Committee's hearing records clearly indicate that need for a new orbiter and the fact that the current space station configuration cannot be built with a three-orbiter fleet. It also would be impossible to have an operational east and west coast launch capability with a three-orbiter fleet. To argue that a new orbiter should not be funded because the President has yet to request it or identify the source of funding is an abrogation of the Committee's responsibilities.

We acknowledge that the White House has finally endorsed the acquisition of a new orbiter and has submitted a fiscal year 1987 budget amendment to initiate acquisition. However, we are concerned with the lack of information that has accompanied the request and with the current confusion as to whether NASA will or will not be required to absorb the cost of the new orbiter from existing program activities. The civilian space program is more than the shuttle and the space station, despite the critical role that they play in the Nation's space program. The civilian space program also consists of space science, space applications, and space research and development activities that are critical to U.S. leadership in space and in technology development. NASA should not be forced to absorb the cost of the new orbiter. The new shuttle is critical to the national and economic security of the United States and should be in addition to the NASA budget baseline. To do otherwise would threaten the future of the civilian space program and NASA.

The history of NASA and our civilian space program has been one of distinction and accomplishment, and we should not let the events of January 1986 totally distort that reality. Yes, there was a tragedy, and worse yet, it was avoidable. Let us not add to the dimension of that tragedy by neglecting the civilian space program at the most critical juncture of its short life. We have all basked in the glory of NASA's accomplishments, and now it is time for the Committee to support actively the civilian space program and to be engaged actively in the current policy debates and discussions.

For example, the recent report of the Presidential Commission on Space, the Paine Commission, outlines an exciting vision of the future of the civilian space program, a vision of what America could do if it made the necessary commitments. More importantly, the Commission in its report, "Pioneering the Space Frontier," gives us a blueprint for the future that would inspire our youth and further their interest in science, mathematics and engineering. The Paine Commission report was inspired by legislation introduced by Senator Hollings, who was concerned about the direction of the civilian space program, a concern we all share. Included in the recommendations of the Paine Commission was one recommendation so critical to the future technological leadership of the United States that it was quickly endorsed by the members of the Senate Commerce Committee. That recommendation was to increase the advanced technology research base for future space activities. We are pleased that this amendment, first included in the civilian space restoration bill, has been incorporated into S. 2714, as reported by the committee.

But combined with our optimism about the future is a note of caution—this Committee must fulfill its oversight responsibility if NASA and the space program are to stay on track. Now more than ever, the Committee and the subcommittee must work to formulate and shape a realistic space policy that will ensure U.S. leadership in space and will prepare us for the challenges of the 1980's and 1990's. While the United States has been trying to recover from the wavering as to where to go, what to do, and how aggressively to proceed with its space program, the Soviet Union, the European Space Agency, Japan, China, India, and many other nations are entering the space race with ardor and resolve. During the same period the United States has been reviewing the causes of the shuttle disaster and considering possible fixes, the Soviet Union had a successful encounter with Halley's Comet deployed a third generation space station, and joyously celebrated the 25th anniversary of Yuri Gagarin's historic flight. The 25th anniversary of U.S. astronaut Alan Shepard's flight on May 5 went virtually unnoticed in this country.

Perhaps now we should all take time to read the hearing records from the late 1950's when legislation to create NASA was being considered. There are many parallels between the late 1950's and today. Perhaps this quote from then Senator Lyndon Baines Johnson best summarizes the challenge then and the challenge today:

I believe that it is entirely fair to say that seldom, if ever, has a Congress and an administration faced a more challenging task. We are dealing with a dimension—not a

force. We are dealing with the unknown—not the known. While the present is urgent, the real imperative is the future. What we do now may very well decide, in a large sense, what our Nation is to be 20 years and 50 years and 100 years from now—and, of no lesser importance, our decisions today can have the greatest influence upon whether the world moves toward a millennium of peace or plunges recklessly towards Armageddon.

We are ready to respond to that challenge and hope that in the future the Committee and subcommittee will actively work to get the space program back on its feet and headed in the right direction.

ERNEST F. HOLLINGS.
DONALD W. RIEGLE, Jr.
ALBERT GORE, Jr.
JOHN D. ROCKEFELLER IV.

